The Glasgow Naturalist

Including the
Proceedings of the Urban Biodiversity Conference 2010

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THE GLASGOW NATURAL HISTORY SOCIETY

Glasgow Natural History Society

(formerly The Andersonian Naturalists of Glasgow)

The Glasgow Natural History Society is a registered charity (SCO 12586) with approximately 250 members living in Glasgow, the West of Scotland, throughout the UK and overseas. The Society arranges a full programme of events throughout the year in Glasgow and district and occasionally further afield. These are at both specialist and popular level, designed to bring together the amateur and the professional, the expert and the beginner.

The Society has its own library, and provides grants for the study of natural history. Further details about the Society can be found at www.gnhs.org.uk or by contacting the Secretary, The Glasgow Natural History Society, c/o Graham Kerr (Zoology) Building, University of Glasgow, Glasgow, G12 8QQ, Scotland (E-mail: info@gnhs.org.uk). The Society has microscopes and some field equipment that can be used by members. Please contact the Membership Secretary Mr Richard Weddle at the address above for further details.

The Glasgow Naturalist

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Publications of the Glasgow Natural History Society

The Society has published a number of books on the flora and fauna of the West of Scotland. Full details can be found at www.gnhs.org.uk/publications.html

Front cover
Small tortoiseshell butterfly (*Aglais urticae*) on the M8 motorway verge, Glasgow. Photo: Cath Seott.

Back Cover
Buff-tailed bumblebee (*Bombus terrestris*) in a wildflower meadow in Kelvingrove Park, Glasgow. Photo: Cath Scott.

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Volume 25 Part 4

Contents

EDITORIAL
Impacts of television on natural history. D. J. McCafferty 1

PROCEEDINGS OF THE BIODIVERSITY CONFERENCE 3

FULL PAPERS
From whaling to whale watching: a history of cetaceans in Scotland. E. C. M. Parsons 53
The moth assemblages of Flanders moss, Stirlingshire. J. T. Knowler 59
Diversity of wild plants in low-maintenance Scottish suburban garden. Then and now – 1986 and 2011. M. O'Reilley 71
The professor Blodwen Lloyd Binns Bequest: its contribution to the development of Glasgow's Natural History Society. J. R. Downie, M. McKinnon, P. Macpherson, D. McCafferty & R. Weddle 79
Gartcosh great crested newts: the story so far. D. C. McNeill, J. R. Downie & B. Ross 87
Vegetation and 'site florulas' of islands in West Loch Roag, Outer Hebrides. P. A. Smith & J. McIntosh 93
A review of the incidence of cyanobacteria (blue-green algae) in surface waters in Scotland including potential effects of climate change, with a list of the common species and new records from the Scottish Environmental Protection Agency. J. T. Krokowski, P. Lang, A. Bell, N. Broad, J. Clayton, I. Milne, M. Nicolson, A. Ross & N. Ross 99
Effects of fertilisers on vegetation of ultrabasic terraces (1965-2010): Isle of Rum, Scotland. J. A. Gilbert & K. R. Butt 105
Long term dynamics in Scottish saltmarsh plant communities. R. B. Taubert & K. J. Murphy 111

SHORT NOTES
Interesting Aculeate records from Glasgow, including eight new species records from Lanarkshire, with reflections on their wider distribution in Southern Scotland. J. Robinson & C. Fiedler 119
The Entomology Collection of Dr Clifford Edwards (1913-2009) in Glasgow Museums. J. Robinson 124
Adventures with Amphibians. J. R. Downie 125
The migrant moth, small marbled *Eublemma parva*, in central Scotland 2011. C. Convery, D. Collis & G. Collis 129
The Australian landhopper, *Arcitalitrus dorrieni* (Hunt, 1925), Crustacea, Amphipoda, in Glasgow. E. G. Hancock . 130
Miscellaneous invertebrates recorded from the Outer Hebrides, 2010. J. H. Bratton 130
A photograph of a teacher-training course in marine zoology at Millport (1914). P. G. Moore 132
Correction to the statistical note in 'Gulliver, R., 2011. Patterns of flowering on continuously-grazed dune and machair on Colonsay. The Glasgow Naturalist 25 (3) 19-28'. R. Gulliver 133
The most northerly documented record of the green alga *Hydrodictyon reticulatum* (water-net) in the UK. A. McManus 134
Hoverfly species (Diptera, Syrphidae) collected near Rowardennan, Loch Lomondside, August, 2011. E. G. Hancock 135
First record of larval sea lamprey *Petromyzon marinus* L. in the Endrick Water, Loch Lomond. J. B. Hume & C. E. Adams 137
A record of the aurochs, *Bos primigenius*, from Morayshire. A. C. Kitchener & J. Doune 138
The rare green alga *Pediastrum privum* (Chlorophyta, Sphaeropleales) in a Scottish kettle loch: new to British freshwaters. P. Lang, J. Krokowski, N. Ross & R. Doughty 139
First records of the pygmy sperm whale, *Kogia breviceps*, in Scotland. A. C. Kitchener, J. S. Herman, R. J. Reid & N. Anderson 142
Scottish Centre for Ecology and the Natural Environment and Glasgow Natural History Society Photographic Competition 2012 147

OBITUARIES 149

BOOK REVIEWS 151

PROCEEDINGS 157

EDITORIAL

Impacts of television on natural history

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Have you noticed how many people discuss natural history after watching an episode of BBC *Springwatch* or following a David Attenborough documentary? For most people television and digital media now constitute a substantial source of information about the natural world. There can be no doubt that television plays a significant part in our lives as it is estimated that in Scotland we watch on average 4.2 hours of television per day (BBC Scotland 2010). Susanna Curtin (In press) argues that wildlife television programmes shape the way in which we develop our emotional relationship with wildlife and indeed influence the growing trend in wildlife tourism particularly in Scotland. In *'The Effect of British Natural History Television Programmes: Animal Representations and Wildlife Tourism'* soon to be published, she highlights the fact that in the UK wildlife programmes are watched by over 50% of men and women and natural history topics are in the top five of favourite television programmes. It is not surprising that a third of visitors to Scotland were influenced in their choice of destination by wildlife/nature television programmes such as BBC *Springwatch*.

Natural history programmes have grown in popularity since the 1960s and therefore for most of us they have contributed to our knowledge and understanding of natural history. Are there any UK biologists alive who have not been influenced by David Attenborough and many other TV naturalists? Wildlife documentaries are predominantly associated with large charismatic mega-fauna, often anthropomorphising the lives of animals and focusing on the exciting moments of fighting, reproduction and predation. There could be a tendency for broadcasting to bias our knowledge of the natural world away from the less spectacular aspects of natural history. Thankfully there appears to be some evidence that we continue to be fascinated by the less exotic species we share our cities and gardens with. This edition of *The Glasgow Naturalist* features the *Proceedings of the Urban Biodiversity Conference* that was held at the University of Glasgow in 2010 which demonstrated how we value our urban wildlife as well as the charismatic species found in wild areas of Scotland and beyond. Indeed many fascinating insights into the lives of animals and plants have recently been filmed in the centres of large cities such as Glasgow.

For the first time in its history, papers from *The Glasgow Naturalist* have been published online before appearing in print. Natural history and naturalists are certainly moving with the times and as is the case with many aspects of our lives we cannot ignore the influence of the media on our knowledge, enjoyment and relationship with the natural world.

ACKNOWLEDGEMENTS

I would like to thank all the authors and reviewers for their time and effort which have ensured the high quality science and scholarship of this journal. Iain Wilkie took on editorial work for this edition for which I am extremely grateful. I am indebted to Ruth Maclachlan for all secretarial work for the journal and especially her patience with my formatting requests. Thanks to Norman Tait for photographic work and Bob Gray for compiling the Book Reviews. Without all their efforts this volume would not have been possible.

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PROCEEDINGS OF THE BIODIVERSITY CONFERENCE

Urban Biodiversity: Successes and Challenges: Introduction

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Early in 2009, GNHS Council discussed how we might respond to International Year of Biodiversity, designated for 2010. We quickly agreed that the most appropriate theme for a city-based natural history society would be a focus on urban biodiversity: after all, it is still the case that too many people think of biodiversity as something you only find 'out there' in the countryside. So we felt that a conference discussing the range of biodiversity in towns and cities would be valuable. We were delighted when Jim Coyle of Glasgow City Council's biodiversity team gave immediate support and we soon assembled a steering group comprising representation from GNHS, RSPB Glasgow, SWT, Glasgow Museums and GCC's Biodiversity team. An early meeting agreed on the title: 'Urban Biodiversity – successes and challenges', because we wanted to describe and celebrate the successes achieved in conserving and enhancing biodiversity in Glasgow and other towns and cities, but also to discuss the challenges we still face in making further progress.

Timing was easy to decide on. Two factors settled the final weekend of October 2010. First, the United Nations Convention on Biodiversity meeting, planned to achieve agreement on new conservation targets was scheduled to end in Nagoya, Japan on Friday 29th October. Second, a new book, Co-ordinated by Glasgow Museums 'Wildlife around Glasgow' was due to be launched during the same week.

We decided early on a two-day meeting and that it should be over the weekend (the debate between weekend and weekdays for such a meeting is a tricky one, but venues are easier at weekends). The plan was to devote the Saturday to formal presentations: these would deal first with policy issues, achievements and benefits. We were very keen to ensure that the meeting would highlight the benefits of urban biodiversity to people. Saturday would also cover case histories, including single species, groups and unusual habitats, both by talks and by posters. We also hoped to entice some high level political presence and were very pleased when Roseanna Cunningham, Minister of the Environment, agreed to open the conference.
Sunday was to be a more practical, interactive day with the morning devoted to participative workshops with choices of topics, and the afternoon to excursions to interesting biodiversity locations within easy distance: we realised the riskiness of this in terms of weather and impending darkness on the last Sunday of October.

Over approximately monthly meetings from October 2009 the programme you see before you came together. We were very pleased by the response from our invited speakers: this seemed to be a meeting people wanted to contribute to.

What of the omens for success? First, 'Wildlife around Glasgow' was successfully launched on the Thursday before the conference, and a beautiful publication it is. Many congratulations to Richard Sutcliffe and his team. Second, despite gloomy reports during the week, the 190 nations meeting at Nagoya reportedly agreed on 20 new tough biodiversity targets to be met by 2020. It will be up to all of us to ensure that these are not just paper commitments. Third, as I came through campus to get ready for the meeting, a fox crossed my path – now a very common sight in the West End of Glasgow!

I'd like to thank all members of the conference steering group for their input over many meetings and e-mails; also, our funders, Glasgow City Council, the University of Glasgow and the Blodwen Lloyd Binns Bequest. I also acknowledge the honour bestowed by the Lord Provost in providing the Civic Reception which closed the proceedings. Most importantly, I must thank Richard Weddle whose tireless efforts made this conference possible.

Urban Biodiversity: Successes and Challenges: Civic welcome speech

Bailie Nina Baker

Glasgow City Council

Ladies, gentlemen and distinguished guests, it is my great pleasure to welcome you to this event, on behalf of the Lord Provost and people of the city of Glasgow. On the eve of your 160th anniversary, the Glasgow Natural History Society is to be congratulated for bringing together The University of Glasgow, RSPB,

Glasgow City Council, Culture and Sport Glasgow as was, now of course known as Glasgow Life, and the Scottish Wildlife Trust to hold this conference marking the International Year of Biodiversity.

With the vast majority of our nation's population living in urban areas, the quality of urban open spaces can have a significant effect on their attitudes to the natural world more generally. Professor Jim Dickson and others' ground breaking book on the plants in our city showed us how even apparently grotty brownfield sites are oases in otherwise less favourable urban environments and help the overall biodiversity of the city. This work has now been complemented by the recent fauna surveys by the volunteers of the Biodiversity in Glasgow project. With the continuing shortage of allotment plots in areas of high demand, the council's policy to help so-called Stalled Development sites become temporary community greenspaces will be welcome to many and it is to be hoped that the owners of such spaces see the benefits they can bring.

Your fascinating programme of talks looks at these wider issues as well as the micro-studies of particular environments, such as bings and wildlife corridors and of particular wildlife such as waterbeetles and epigeal invertebrates – do I assume this means our good friends the earthworms?(Audience response: No, these are surface-livers like slaters, millipedes and ground beetles). With more and more of our schools being not only Ecoschools but also gardening and food growing schools, I am sure our younger generation have a keen eye for Glasgow's biodiversity. And here in the university that enthusiasm is taken to the professional levels. You will be asked to consider if Glasgow is as green as its nickname, dear green place, but I am sure with the council staff, professionals and amateur enthusiasts' energy represented today, we can look forward to every effort being put towards improving the biodiversity in the future. So, I am pleased to provide this civic welcome half-way through your conference and wish you a successful and interesting event.

Urban Biodiversity: Successes and Challenges: Nature in the city

Roseanna Cunningham – MSP

Minister for the Environment - Scottish Government

Urban environments are often thought of as human environments. After all, our towns and cities are home to over 80% of Scotland's population. But urban environments are so much more than this. Each town and city has its own unique mosaic of habitats and ecosystems. Gardens, parks, allotments, brownfield sites, industrial sites, rivers, ponds and even graveyards all provide different niches for the thousands of species that share our urban landscape.

With all these different habitats on the doorstep it isn't surprising that urban environments are where most people have the opportunity to experience the natural world. But while this is obvious to us here today, it is not always so clear to other people living in urban environments – less than half of Scots get into the outdoors at least once a week. This is something that needs to change.

Being outdoors and around nature brings so many benefits. It can reduce stress and improve physical and mental health. In short it improves residents' quality of life. It is the Greenspace in our cities that can provide people with a quick and easy escape from the hubbub of city life. This is why SNH are promoting the Simple Pleasures these areas can bring. This is a new campaign aimed at getting the public out and about in their cities and introducing them to the wildlife within it. Over 20% of Glasgow is green space so the opportunities to experience nature really are on your doorstep.

As part of the Simple Pleasures campaign SNH have identified routes and suggested places to visit in and around Glasgow. Similar materials are being developed for other cities and I hope they become a useful resource for those of you working with the public. I understand that this conference is also linked to the publication of the book 'Wildlife around Glasgow', so the materials are out there that can help introduce people to the wonders of nature without the need for expensive equipment or extensive planning.

Of course, these opportunities only exist if the networks of green and blue space are properly managed. The ecological footprint of any city extends far beyond its boundaries and development pressures within the city limits can cause conflict. There is no easy solution to these pressures but planning and managing urban environments in the right way can have significant positive impacts. Connecting cities with the environment around them through habitat networks and limiting the impact of development on the surrounding ecosystems are vital parts to this. Climate change will add new pressures to the urban environment and working with the biodiversity that supports our ecosystems is one of the best ways of adapting and mitigating against its effects. We're promoting such policies through initiatives like the Central Scotland Green Network which is a priority under the National Planning Framework. This is already enhancing greenspaces, promoting healthier lifestyles, greater biodiversity, stronger communities and economic opportunity.

Many of you will be involved in making this a reality on the ground in many different ways. For example, Sustainable urban drainage (SUD) schemes help

mitigate against flooding and provide habitat for a variety of species. Promoting local food growing engages local people and helps reduce our overall carbon footprint. Householders can do their bit too by growing wildlife friendly plants, avoiding invasive non-native species and carefully composting what they can. When the impact of all these different initiatives is added together we end up with rich urban environments which benefit all the species that live in them. Not least the human community.

I've briefly touched on a few themes which I know you will be discussing in more detail over the next couple of days. As you might know, discussions have also been ongoing recently in Nagoya, Japan about the UN Convention on Biological Diversity. I know such high level debate can often seem far removed from the day to day delivery of biodiversity conservation and it is easy to be cynical about the process. But these discussions included a specific focus on cities and biodiversity. And while it's too early to have fully digested the outputs and what our response will be to it, I'm sure those aspects of the discussion in particular will be of interest to all of you.
Unfortunately, due to other commitments, I am not able to stay for the rest of the conference but from looking at the agenda and field trips I am sure you will have an interesting and productive two days.

(This is the formal version of the speech that the Minister delivered at the opening of the Conference).

Urban Biodiversity: Successes and Challenges: The next generation: environmental education with the RSPB

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An RSPB field teaching site was established at Kelvingrove Museum and Kelvingrove Park in 2007. It provides sessions for primary schools on woodlands, urban wildlife, birds, conservation and a sensory walk for infants.
All the sessions are based on the Scottish Curriculum for Excellence and involve active outdoor learning. The programme is agreed with the teacher before the visit and the quality of the service is evaluated by users and by the RSPB Education Officer. The RSPB field teaching scheme is a holder of the nationally accredited Learning Outside the Classroom Quality Badge.
Around 2000 children visit the RSPB at Kelvingrove every year. Learning to appreciate the biodiversity in local parks encourages children to care for their own school grounds and gardens. A lack of knowledge about and experience of seeing wildlife is apparent in many Glasgow children making field trips a valuable part of school projects.

Urban Biodiversity: Successes and Challenges: Biodiversity on bings

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ABSTRACT
The West Lothian oil-shale bings are important havens of biodiversity at both a local and a national (UK) level. They are examples of true primary succession and provide a refuge for locally rare species, both plant and animal, in an urban/ industrial/ agricultural landscape making them important to conservation and increased local biodiversity.

THE SITES
The oil shale bings of West Lothian are piles of industrial waste; a by-product of Scotland's first oil industry in the 1850s. Historically they are of great importance (Harvie, 2010) and given their history it is perhaps not surprising that Greendykes and Five Sisters are now protected as designated Scottish Industrial Heritage Sites. Other bing sites are protected for more remarkable reasons. Addiewell North is a Scottish Wildlife Trust Nature Reserve, Oakbank is part of Almondell Country Park and all of the bings together make up a major habitat in West Lothian's biodiversity plan (Harvie, 2005a).

THE FLORA
The West Lothian shale bings are of great ecological and scientific importance. They are examples of a distinctive and rare type of post-industrial waste that is unique within Britain. They are also examples of sites of primary succession. Primary sites are only found naturally on sand dunes, glaciers and volcanoes; all of which are very uncommon in Britain. Habitats within the bings vary from almost bare substrate to semi-natural grassland, heather scrub and pioneering birch woodland. Differences in the age and size of the bings, how they have been managed, available seed sources, substrate type and soil chemistry all contribute to the habitats and their vegetation. They provide refuges for a wide range of animals and plants that are under increasing pressure in the surrounding area from

farming and urban development. The diversity of plant species on the bings is considerable and the sites are home to more than 350 plant species (Harvie, 2005b). This is more than have been recorded on the Ben Nevis SSSI

Some of the bings support several plant species not found elsewhere in the county. *Buxbaumia aphylla* Hedw. is a rare moss in Britain that has been recorded in sizeable populations at Addiewell bing for more than 35 years. A small population of the montane lichen *Stereocaulon saxatile* is found on Addiewell bing and extensive colonies of three related and locally rare species *S. leucophaeopsis*, *S. nanodes* and *S. pileatum* are found on Philpstoun bing. Faucheldean bing is noted for colonies of stag's-horn clubmoss and alpine clubmoss (*Lycopodium clavatum; Diphasiastrum alpinum*), species that are more usually associated with montane habitats, and renowned for a diverse orchid population including broad helleborine, great butterfly orchid and early purple orchid (*Epipactis helleborine; Platanthera chlorantha; Orchis mascula*). On the plateaued summit of Greendykes a species poor calcareous grassland has established from self seeding species above the bare steep sides of the bing. Genetically distinct birch (*Betula pendula*) woodland has established naturally at the base of the tiny bing at Mid Breich, complete with many of the associated ground flora and bryophyte species of long established native woodlands. There are also exotics in the form of garden escapes that are well established on many bing sites. Opium poppies (*Papavar somniferum*) grow in profusion on more than one bing. Old elder trees growing on many of the bings are an astounding source of epiphytic lichen and moss diversity. Almost half of all the bryophytes that are recorded in Britain are present in the Lothians and shale bing habitats are identified as important to the bryophyte flora (Harvie, 2007).

THE FAUNA

Locally rare animals are also often seen, especially on early morning visits. These include hares, red grouse, badgers, sky larks and common blue butterflies (*Lepus europaeus; Lagopus lagopus scotica; Meles meles; Alauda arvensis; Polyommatus icarus*). The bings are home to foxes (*Vulpes vulpes*), often seen in family groups, suggesting that many unobserved smaller fauna are also inhabiting the sites. Insect records from Addiewell bing include ringlet butterfly (*Aphantopus hyperantus*), very rare in central Scotland, and a first recording of ten-spot ladybird (*Adalia decapunctata*) in the county. Additional butterfly species recorded at Faucheldean include green-veined white, small heath and common blue (*Pieris napi; Coenonympha pamphilus; Polyommatus icarus*). Forty seven species of bird were recorded at Addiewell during 1997, including 30 species with permanent breeding territories and nine local habitat indicator species, such as the bullfinch, kestrel and yellowhammer (*Pyrrhula pyrrhula; Falco tinnunculus; Emberiza citrinella*) (Harvie, 2007).

VULNERABILITY

The destruction and landscaping of shale bings is a severe threat to some of the rarer plant species, both locally and nationally. Of the 27 bings extant when shale extraction ceased in 1962 only 19 remain. Many of these are slowly being demolished and the continued, recent loss of sites like Philpstoun (to industry) and Niddrie (to housing development) can only be detrimental to the biodiversity of the county of West Lothian.

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Urban Biodiversity: Successes and Challenges: Jupiter Urban Wildlife Centre

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Scottish Wildlife Trust's Jupiter Urban Wildlife Centre is situated in the middle of Grangemouth. The 4 hectares are leased from the chemical company Calachem. It is a fine example of land reclamation for nature conservation. In 1989, the chemical giant ICI approached SWT regarding setting up a demonstration wildlife garden on an abandoned part of their Grangemouth site. This area had been a railway siding. Upon acquisition, it was covered in a mixture of sparse grassland, scattered scrub and marshy areas. Jupiter was opened to the public in 1992.

Jupiter can be divided into three areas; wildlife gardens, habitat creation area and "wilderness woodland." The habitat creation area and wildlife gardens contain complex habitat mosaics often with unusual combinations of species, due to their interesting history, with some species having been

present when the area was wasteland, the deliberate creation of certain habitats and a combination of active management and natural succession over the succeeding years.

The wildlife gardens show ideas for creating wildlife friendly spaees. The habitat creation area consists of a number of habitats with artificial origins: wetlands, wildflower rich grasslands and small woodlands. The regenerated "wilderness" woodland is an excellent example of the potential of wasteland if allowed to develop on its own.

Thanks to the rich array of habitats and careful management work, Jupiter supports a wealth of biodiversity. Over 360 species of flowering plant have been recorded and attraet many invertebrates. There are records of over 50 species of bird. Mammals are more rarely seen, although some species have been recorded. The ponds support breeding populations of amphibians.

Jupiter is also an important place for people. Curriculum linked edueation sessions, public events programmes, and volunteering are all popular. SWT's partner organisation at Jupiter, BTCV Scotland, runs a Wildflower Nursery and a Green Gym. Sceondary schools have been involved in exeiting projects, designing and creating mosaics, murals and an outdoor classroom.

Urban Biodiversity: Successes and Challenges: Glasgow's local biodiversity – the way forward?

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There were 24 attendees at the 'Glasgow's Local Biodiversity – the way forward?' workshop, where people were asked to eonsider the following four questions:

1. Do you consider that the Glasgow Biodiversity Partnership is doing enough for biodiversity in the City?
2. What does your local greenspace need to make it good for biodiversity?
3. How can the Partnership best communicate and engage with 'hard to reach' groups?
4. What can *you* personally do to improve and enhance local biodiversity?

The results of the workshop, combined with a concurrent on-line questionnaire about biodiversity provision in the City (at www.glasgow.gov.uk/biodiversity) will help shape the future direction of the Local Biodiversity Action Plan (LBAP), which is being updated. Due to time constraints, only questions 1-3 were considered and as the first two questions were linked the responses to them have been combined. The key responses are summarised here:

Q. Do you consider that the Glasgow Biodiversity Partnership is doing enough for biodiversity in the City?

Q. What does your local greenspace need to make it good for biodiversity?

'More work needed in city centre areas. Everything happens north of the river.
Use the Commonwealth Games to showcase biodiversity to visitors. Need better biological recording, brownfield sites need surveyed. Need better co-ordination between conservationists and contractors. Make sure greenspaces are high quality. Push for more allotments in the City. Provide more awareness of sites that communities can work on. Provide biodiversity interpretation in local parks. Combat vandalism by encouraging community participation and schools involvement.'

Q. How can the Partnership best communicate and engage with 'hard to reach' groups?

'Engage more with local industries and eompanies and make better business links overall. Raise biodiversity profile by establishing a volunteer system linking various organisations. Target unemployed people at job centres to encourage volunteering – advertise. Give youth group talks and activities. Use social media such as facebook. Think about unusual media like drama groups, art and music groups – put on a biodiversity theatre production. Link more with secondary schools. Wider community work with different ethnic groups, taking 'whole' communities out on site. Use radio shows, places of worship and other venues to promote biodiversity.'

The update of the LBAP will include the development of a Community Engagement Plan which will allow local people and interest groups to help set local targets for biodiversity, and to consider the topics and queries above. The programme of Local Nature Reserves (LNRs) designation and development will help achieve many of the concerns raised. Linn Park on the south side, will soon be designated as an LNR. Darnley Mill is a proposed LNR, also on the south side of the City. There are LNR leaflets which are designed to raise awareness of biodiversity and the importance of these sites for people and nature. There are already a number of volunteers helping at our LNRs and it is hoped these numbers will increase in the years ahead.

New ideas such as using drama and social media to raise awareness of biodiversity could add a different strand of actions to the updated LBAP.

There are clearly a number of issues which have been raised by discussion within the Workshop and opportunities for these issues to be addressed by the new LBAP and any related policies and strategies.

Urban Biodiversity: Successes and Challenges: Connecting habitats and communities workshop

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Urban environments are becoming increasingly valuable habitats for a wide variety of species. As these areas are associated with large populations of people there has to be a balance between protecting valuable habitats and providing suitable housing and related industry. Local communities have a considerable amount to offer and gain from being involved in improving their local area for wildlife.

Froglife's Living Waters projects are working in London and Glasgow to engage with local communities and help complete habitat creation and restoration work on standing open water habitats. This work is being carried out in partnership with Glasgow City Council and relevant London Boroughs, and is supported by local volunteer and 'friends of' groups from different urban parks. To promote sustainability of habitat work, communities are involved where possible on site and opportunities are provided to teach survey and practical conservation techniques.

Froglife designed the workshop 'Connecting Habitats and Communities' to promote the importance of community involvement and raise awareness of enhancing habitats and creating essential wildlife corridors to increase connectivity between sites.

The workshop commenced with a short presentation introducing Froglife's work followed by an interactive discussion with the audience. Eighteen people attended the workshop and were split into four groups. The groups were provided with a map of an urban site featuring a park, a school, ponds, hedgerows, ditches and allotments. A role-playing exercise was completed with each attendee being assigned a role as a different stakeholder with an interest in the local area. The character briefs included: a Head Teacher of the local school, a Council Park Manager/ Biodiversity Officer, and a representative from each of the following groups: a Friends of Group, a Local Natural History Society, a Wildlife Charity Officer and a Local Allotment forum.

The groups held discussions in which each person gave suggestions from their point of view to provoke discussion and develop ideas for the area. This included how they would improve the selected site for wildlife, a proposed methodology for completing this work, and suggestions on how to involve members of the community.

There were many aspects to cover in the session, but each group was able to provide one suggestion from their discussion to share with the rest of the audience. Groups had also written down a number of other ideas. Some similar themes emerged, as well as new initiatives for this type of urban site.

Examples provided from the group discussions are shown below:

- Pond creation and management - connecting and improving habitats including areas beyond the site boundary.
- Conducting surveys of flora and fauna and mapping what is present to improve records.
- Encouraging more local people to assist and gain new skills.
- Training and sharing knowledge across different community groups on wildlife friendly gardening, vegetable growing, pond creation and surveying.
- Working with local groups such as allotment users to save resources, for example water and tools.
- Improving amenity grassland with wildflower meadows. Connecting habitats and encouraging communities to get involved through planting and enjoying the aesthetic value of wildflower meadows. Creating more hedgerows to connect habitats.
- Writing a wildlife column for a local newspaper to share news e.g. nature diary or update community with recent work completed.

To conclude the workshop the site for which participants had made their suggestions was revealed as Foots Cray Meadows in South London. Work completed by Froglife in the area was also discussed, including enhancement of one pond and the creation of eight new ponds. Work is also taking place to improve the surrounding terrestrial habitats not only for amphibians and reptiles but also wider biodiversity. Friends of Foots Cray Meadows have been involved with Froglife and support the habitat improvement work.

The workshop was presented by Eilidh Spence and Sam Taylor from Froglife. Eilidh is the Glasgow Living Water Project Officer and can be contacted by email at eilidh.spence@froglife.org, or 01413390737. Eilidh is based at the University of Glasgow in the Graham Kerr Building. Sam is Froglife's Head of Communication and deputy CEO and is based at Froglife's headquarters in Peterborough. Sam can be contacted by email at sam.taylor@froglife.org.

Urban Biodiversity: Successes and Challenges: Excursion to Bingham's pond

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Bingham's Pond (Fig. 1), situated just off the busy Great Western Road, Glasgow, was once a popular skating and boating pond. It became the subject of complaints by local residents concerning the rundown state of the pond and swan droppings making the path slippery and the water dirty. The large numbers of mute swans were dependent on bread as the pond supported almost no natural vegetation.

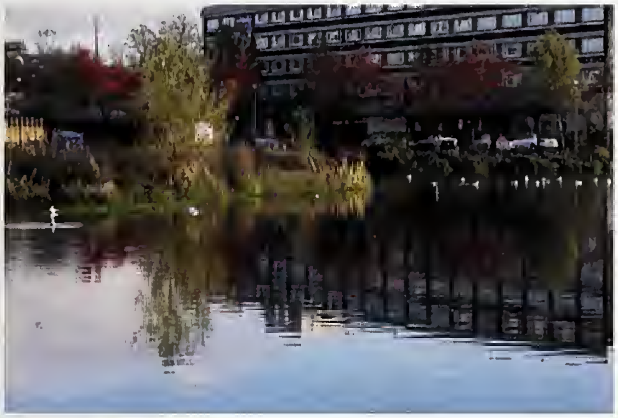

Fig. 1. Bingham's Pond

In consultation with the local Community Council, it was decided to naturalise the pond to provide a more attractive place for the local people to enjoy and to enhance the biodiversity. It was hoped that by providing suitable habitat, a pair of breeding mute swans might be attracted to the pond and so control the large numbers of non-breeding swans, thus alleviating the perceived problem of the droppings and water quality.

A steering group from the local community was set up to carry the project forward. In February 2003, the water level was lowered and many of the waterbirds flew off. 55 swans remained. These were rounded up and transferred to Hogganfield Loch, NE Glasgow. Work then started to create two islands and a shallow shelf area around them and most of the perimeter of the pond.

Over 7000 plants of over 20 species were planted. Wildflower mixes were seeded on the islands and the edge of the pond above the water level. The bulk of the plants were collected elsewhere in Glasgow. The plants were therefore of local provenance and importantly brought in aquatic invertebrates among the roots, which 'inoculated' Bingham's Pond, thus enhancing the biodiversity of the site. A frog ramp was built to enable young common frogs to reach suitable habitat for feeding and hibernation and interpretation boards were erected.

In the first year after naturalisation, mute swans, mallard, tufted duck, moorhen and coot bred. Surveys of the aquatic invertebrates of the pond before and after naturalisation, has revealed a large increase in the number of species present in the pond.

As part of the Urban Biodiversity Conference 2010 an excursion to Bingham's Pond was held at 2pm on 31st October. This session was attended by 14 people and blessed with quite good weather. Sheila Russell from Glasgow City Council led the group around the pond explaining the enhancement process and work completed on site.

The excursion was concluded with examples of pond restoration and creation work in Glasgow through Froglife's Living Water Project, provided by Project officer Eilidh Spence. Examples included restoration work at Newlands Park, Dawsholm LNR, and Alexandra Park and also pond creation work at Dams to Darnley Country Park and Windlaw Marsh. Proposed future work and the expansion of the project into North Lanarkshire were also discussed.

The pond enhancement work at Bingham's Pond through Glasgow City Council will continue to be used as a demonstration site. The aim is to encourage landowners and stakeholders to care for standing open waters and contribute towards local biodiversity action plans to protect these valuable habitats for wildlife.

Urban Biodiversity: Successes and Challenges: Posters - Bumblebee Conservation Trust

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Urban habitats provide valuable nesting opportunities and forage resources for bumblebees. Six species are commonly found in gardens, providing a significant, free, pollination service for fruit and vegetables, and of course wildflowers. Planting and management of bumblebee-friendly flowers in parks, gardens, orchards

and other areas helps deliver substantial benefits for this crucial group of 'keystone' pollinators.
The first British record of the tree bumblebee *Bombus hypnorum* was in 2001 on the Hampshire/Wiltshire border (Fig. 1). A population quickly became established and since 2007 the range has rapidly expanded to cover much of England. The species has not yet been recorded in Scotland. A distinctive species often found in urban areas, recording by the public is encouraged to monitor this colonisation event.

Fig 1. Tree bumblebee (*Bombus hypnorum*)
Photo credit: Bumblebee Conservation Trust.

Urban Biodiversity: Successes and Challenges: Challenges in Glasgow's urban woodlands

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Glasgow's woodlands are diverse in location from stand-alone woods to park woodlands and Local Nature Reserves, yet whilst there a differing types of woodlands across the city many of the mature woodlands are not diverse in either species or age structures. Glasgow City Council utilises sustainable silvicultural management systems to ensure woodland cover in perpetuity whilst increasing biodiversity through developing native species elements and age structures of woodlands. There are many challenges to successfully meet the woodland management objectives, including managing woodlands as a social resource as well as an environmental resource.

Urban Biodiversity: Successes and Challenges: Local nature reserves in Glasgow

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INTRODUCTION

The City of Glasgow, eommonly known as the 'dear green place', has seven Local Nature Reserves (LNRs). What is meant by the term LNR? Put simply, LNRs are:

- Statutory designations made under the National Parks & Access to the Countryside Act 1949.
- Special places which are rich in wildlife. generally
- Generally, readily accessible and suitable for people to visit and enjoy.

The LNRs - at Garscadden Wood, Dawsholm Park, Robroyston Park, Hogganfield Park, Cardowan Moss, Bishop Loch and Commonhead Moss - were declared by the land owner of all seven sites, Glasgow City Council (GCC). In declaring these sites, GCC aims to:

- Protect them from unsuitable developments
- Manage and enhance the habitats to help biodiversity flourish
- Improve public access
- Help people understand and become more aware of the importance of the LNR
- Encourage community participation and volunteering.

Description of Glasgow's Local Nature Reserves
All seven LNRs are located north of the River Clyde, generally on the edge of the city's built-up area, from Garscadden Wood in the west to Commonhead Moss in the east (Glasgow City Council 2008). Taking each in turn:
Garscadden Wood was declared a LNR in 2006. It is one of Glasgow's oldest semi-natural woodlands in the city. Its main attractions are its bluebells *Hyacinthoides non-scripta* in late spring and the purple hairstreak butterfly *Neozephyrus quercus*, only one of three places where they can be found in the city.
Dawsholm Park consists mainly of policy and plantation woodland and is important for its woodland bird populations. It was designated as an LNR in 2007.
Robroyston Park, declared in 2006, plays host to grassland, wetland and woodland habitats. These prove

ideal for amphibians, dragonflies and damselflies and a host of birds.

Hogganfield Park was the second LNR to be declared, in 1998. It is a great place to see birds, particularly wildfowl, with winter visitors such as whooper swan *Cygnus cygnus* being a speciality. It is also good for summer migrants and has a good range of butterflies.

Cardowan Moss, also declared in 2006, consists of relatively new plantation woodland with a series of ponds and a relict raised bog. It is good for woodland birds, damselflies and dragonflies and amphibians.

Bishop Loch, the first LNR in the city (1995), was established as a direct result of local people protesting against an open cast coal mining proposal in the vicinity of the loch. They felt sure it would destroy what they described as their "local nature reserve". The planning application for the mining was refused by GCC and thereafter by the Scottish Office, following an appeal and public inquiry. Ironically, the area eventually declared doesn't include any of the actual loch but does include the marshy areas adjoining the loch plus a woodland plantation that plays host to typical woodland birds.

Commonhead Moss, the latest LNR declared in 2009, includes much of the largest raised bog in the city. It is particularly important for its butterflies.

It is worth noting that there are a number of other wildlife sites in the City that are protected and, in some cases, managed for wildlife, e.g. Possil Marsh SWT Reserve. GCC has recognized these sites in its City Plan (Glasgow City Council 2009).

Management of Glasgow's Local Nature Reserves (LNRs)

Generally, each LNR has a steering group of officials, interested agencies and local people. They approve, monitor and amend the Management Plans that were prepared as part of the consultation procedure with SNH. Works on the ground are funded by Council budgets, Landfill Credits and grants; and are implemented by council staff, contractors, volunteers and local people including school children.

Examples of Management Works

Dawsholm Park Local Nature Reserve

This LNR consists mainly of policy and plantation woodland and is important for woodland birds. However, the woodland was being smothered by rhododendron *Rhododendron ponticum* resulting in very little regeneration. This resulted in projects being developed, with the support of Forestry Commission Scotland (FCS) and local residents, aimed at bringing the woodland back to good health for wildlife and people. Specific projects included:

- Woodland thinned
- Rhododendron removed
- Footpaths improved and a new fence erected
- Wildflower meadows created
- Highland cattle introduced
- Interpretation/information provided
- BBC Autumn Watch and other events held.

Further improvements are planned, including:

- The planting of thousands of trees.
- The erection of woodcrete bird nest boxes.

Hogganfield Park

The LNR was declared primarily due to the importance of Hogganfield Loch, however, a number of works have been undertaken to widen the scope and range of habitats and species in the LNR - this is an ongoing project that was first started to demonstrate what could be done in the context of the evolving Biodiversity Plan for the city. Specific projects at Hogganfield Park LNR include:

- Wetlands/ponds created
- BBC SpringWatch and other events held
- Information/interpretation boards erected
- Wildflower meadows created/managed
- Rhododendron removed
- Bird perching posts and loafing pontoon installed
- Loch edges improved.

Further improvements are planned, including:

- Naturalisation of the loch edge at the existing car park
- Creation of a bird viewing and feeding platform.
- Enhanced public access.

The works listed above were undertaken by groups such as BTCV, Scottish Wildlife Trust, Score Environment, BBC and GCC utilising contractors, council staff, volunteers and local school children.

Way Forward

With the current economic crisis and the likely reduction in public sector funding for LNR type work, what can be done to ensure that people can continue to have access to nature on their doorstep?

I would suggest that this can be achieved at both the macro and micro scale.

Firstly, at the macro scale, partnership working is key. For example, through partnerships established with:

(i) *Local Groups*

These include groups such as Froglife, the RSPB Glasgow Local Group, and BTCV.

(ii) *Forestry Commission Scotland (FCS)*

The Council has reached agreement, in principle, for the FCS to take over the day-to-day management of a number of woodlands in the City, including 3 LNRs - Garscadden Wood, Cardowan Moss and Bishop Loch. (Glasgow City Council 2009).

(iii) *Gartloch-Gartcosh Project*

This project covers an area stretching from Hogganfield Park LNR through to Drumpellier Country Park in North Lanarkshire and includes Cardowan Moss, Bishop Loch and Commonhead Moss LNRs. A consultants study (Land Use Consultants 2008), commissioned by a host of agencies, recognised that the area is potentially of national importance for wildlife. This Strategy - the Gartloch-Gartcosh Green Network Strategy - has been well received and a number of agencies have already progressed a variety of projects; e.g. see Section 4 in relation to

Hogganfield Park LNR. It is important that the agencies that commissioned the consultants' report continue to commit to its implementation.

Whilst these projeets and ideas are crueial to ensure the future of LNRs at the maero seale, the future of 'nature' in the City could be said to be in the hands of local people. Why local people? At the 'micro' scale', they already manage a considerable 'green' resource – gardens and allotments. With minor changes to their management, there could be huge benefits for nature without any cost to the publie purse. As a result, green corridors would be created, just like the large scale habitat works proposed through the Gartloch-Gartcosh Project, but on a smaller seale.

Gardens play host to a whole range of wildlife and are key to engaging with current and future generations. Even small spaces ean be managed for wildlife and this in turn eould awaken an interest and quest for knowledge that ean only benefit us all. Having experieneed what ean be attracted to their garden many people will take more of an interest in their LNR or wildlife site. Who here at today's Conferenee hasn't already taken that step? This leads me to my final point. If you care about wildlife or nature you can all make a differenee. If you eare about Glasgow's wildlife I would ask you to consider whether you would join or help create a 'Friends of Glasgow's Loeal Nature Reserves' whose aim would be to lobby and raise funds for Glasgow's wildlife whether at the maero or micro scale. Thank you and remember Glasgow's Wilds Better!

ACKNOWLEDGEMENTS
Much of the work in relation to LNRs in the City is unlikely to have happened without the support and dedieation of the biodiversity & ecology officers in Glasgow City Council.

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Urban Biodiversity: Successes and Challenges: Health-promoting environments – is good greenspace good enough?

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In 2009/2010 greenspaee scotland worked with NHS Health Scotland, Scottish Natural Heritage, Glasgow City Council and the Dundee Environment Partnership to develop and publish what is known as an outcomes framework showing how work to create, maintain and manage greenspaee ean contribute to the delivery of national and local health priorities (greenspaee scotland, 2010). An outcomes framework is a linked series of logic models whieh draw on available evidence to demonstrate the conneetion between planned actions and desired outeomes. This knowledge and approach ean help practitioners to better make the ease for investing time and resources into greenspace and to improve the planning and evaluation of what we do 'on the ground'.

Our researeh project used eight pieces of greenspaee work and a review of existing research literature. The work was set in the eontext of national health priorities which are expressed and interpreted at a local level. We considered three outcomes - increased levels of physical activity; enhanced mental health and wellbeing; reduced health inequalities - which partners felt eould easily be linked to greenspaee. These were a synthesis of outeomes contained in the Dundee and Glasgow Single Outcome Agreements.

This work allowed us to draw a series of important conelusions:

People need to use and/or value greenspace to derive the maximum health benefits.
Most of the health benefits reported in the research require either direet interaction with the environment or some level of positive personal response to the environment.

Simply creating or preserving greenspace is not enough.
Not all greenspace is beneficial to health – poor spaees ean be detrimental to mental health and wellbeing and deter people from taking physical exercise; they ean become the places which communities avoid rather than the plaees where they come together. The potential health benefits of greenspace are only realised if we have the right distribution and mix of spaees.

Appropriate management is crucial.
The potential for delivering health benefits is

dependent on how we manage the spaces that we have. Inappropriate or inflexible management approaches can often exclude people from spaces and fragment communities.

Promotion of healthy uses of greenspace is also essential.

All spaces need some form of active management and promotion of use (even if this is as simple as encouraging local people to adapt spaces to their own uses) - but it goes further than this. Particularly when we look at tackling health inequalities, many of our 'target audience' do not have a culture of using spaces. In such cases, it may be necessary to combine appropriate management of spaces with targeted support for use (from simple publicity and promotion through to behavioural change programmes such as health walks or gardening clubs).

If we are genuine about tackling inequalities, our resources and actions have to be targeted.

Simply improving greenspace (even in ways that are designed to provide healthy environments) will not reduce health inequalities. In practice, what is likely to happen is that those who are most disposed to use greenspace will use it more while many of those experiencing health problems which might be addressed through greenspace will not. This will widen health inequalities. There is a need, therefore, to actively target our actions either on specific geographical areas; specific communities or people experiencing specific health conditions.

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Urban Biodiversity: Successes and Challenges: Glasgow's water beetles

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INTRODUCTION

Water beetles are a well-recorded freshwater group in Britain despite lacking the charisma of dragonflies and the angling interest of mayflies and the like. The conference on urban biodiversity held by the Glasgow Natural History Society in October 2010 provided the stimulus to assess their status in the area.

Water beetles cannot be precisely excised from beetles as a whole. Coleoptera are divided into two major groups, the Adephaga and the Polyphaga. Within the Adephaga the name "Hydradephaga" has been coined to distinguish diving beetles and related species from the ground beetles in the Carabidae. This works fairly well so long as one ignores the fact that many ground beetles are confined to aquatic emergent vegetation or to the water's edge. The Polyphaga are more difficult, with even the major family the Hydrophilidae including some species mainly living in dung, often a wet habitat but not one usually worked with the pond net! The problem is acute for the leaf beetles (Chrysomelidae) and weevils (Curculionidae and Erirhinidae) that live on wetland plants, as sometimes the host range is quite diverse and may even include trees! The acid test applied here is whether the beetles are more likely to be encountered in the pond net wielded by an aquatic coleopterist than in a sweep net swung by a dry-shod coleopterist.

This paper is in two parts, an assessment of the records available from the national recording scheme and a description of a survey of sites in and around Glasgow in 2010.

RECORDING AROUND GLASGOW UP TO 2010

Information was extracted from the national recording data-base for the twenty 10 km squares NS44 in the south-west corner to NS87 in the north-east. This generated 1,644 records of 141 species, the majority from the vice-county of Lanarkshire, with small contributions from the vice-counties of Ayrshire, Renfrewshire, Dunbartonshire, and Stirlingshire. These beetles belong to fifteen families, dominated by the diving beetles in the Dytiscidae (Table 1).

Although 24 species have not been recorded in the area since 1979, 16 were last recorded in the 1980s. Eleven of the latter are typically associated with running water, leaving only another eleven running water species in the list of 101 species recorded from 1990 onwards. However several water beetles specialising in pond habitats have become established in the Glasgow area over a similar period.

The following examples of some species in decline and some on the increase serve to illustrate the range of habitats that can be occupied.

***Noterus clavicornis* (De Geer)** This species is usually referred to as "The Large *Noterus*" because the name *clavicornis* has also been applied to the smaller, flightless *N. crassicornis* (Müller), which is very rare in Scotland. The earliest Scottish record is a little uncertain but by 1946 *N. clavicornis* was in the garden of the greatest proponent of water beetles, Frank Balfour-Browne, in Dumfriesshire and it was first found in Kirkcudbrightshire in 1949. Roy Crowson (1987) reported it in the Glasgow area in Possil Loch in 1985, the same year that the author found it for the first time in Ayrshire. Subsequently it has spread over more of western mainland Scotland (an early record from Raasay was spurious) and was in 2010 found for the first time in the Borders in a well-recorded site in

Roxburghshire. The noterine diving beetles differ from the dytiscid ones mainly in that their wireworm-like larvae live attached to roots and rhizomes of flote-grasses and bogbean, renewing their air supply through their posterior spiracles from aerenchymatous plant tissue, whereas the dytiscids live freely. Consequently noterids are typical of vegetation rafts though *N. clavicornis* can be common among vegetation in ordinary ponds, including in 2010 Durrockstock, Gartcosh, one of the M77 balancing lagoons at the Mearns Box, the Phoenix Industrial Estate, and Robroyston.

Agabus congener **(Thunberg)** This is a scarce dytiscid diving beetle typically found in small hard-bottomed pools on peat. It persists in the Glasgow area on Lenzie Moss having first been reported in the Glasgow area in Robroyston Bog by the Reverend Hislop (1854).

Rhantus suturalis **(Macleay)** The name "supertramp" has been used for this species (Balke *et al.* 2009) respecting its remarkable range, from Ireland to New Zealand. Its ancestry, based on mitochondrial DNA, indicates that about 1.5 million years ago it was an endemic of New Guinea mountains. Now it can be found in a great range of still water habitats north to Caithness. One specimen was found in a newly created pond at Cardowan in 2010: the only earlier record, and there is potential confusion over the names it has received, is from the 19th Century (Young 1856).

Hydroporus ferrugineus **Stephens** A major centre of biodiversity for water beetles is part of the Australian outback where each isolated pocket of subterranean water has it own endemic diving beetle species (e.g. Watts & Humphreys 2009). The northern European fauna is more restricted with only *H. ferrugineus* being truly subterranean though, unlike many subterranean species, it retains eyes. The larva, which is unusually pale, was described from the Speedwell Cavern by Alarie *et al.* (2001). *H. ferrugineus* is often found in wells and can occasionally be pumped to the surface (Young 1980). Professor Crowson's collection, in the Hunterian Museum, has a specimen of *H. ferrugineus* found by Mr H.D. Slack at 384, West George Street, Glasgow in December 1957. This address no longer exists, most likely lost beneath the motorway, but the possibility remains that this species survives in spring systems among the Glaswegian drumlins.

Hygrotus nigrolineatus **(von Steven)** This beetle was first found in Britain in a pit used for gravel extraction in East Kent in 1983 by Ron Carr (1984). It subsequently spread through England as far north as Northumberland by 2004. A single specimen was taken by Craig Macadam in his Glasgow pond survey in May 2010 in a recently excavated pond at Robroyston (NS629683) (Macadam & Foster 2010). This beetle lives on an exposed substratum and cannot tolerate the presence of vegetation.

Helophorus tuberculatus **Gyllenhal** This rare species is 3 mm and black, resembling a fragment of charcoal (Angus 1992). It lives on wet moorland that has been burnt, its principal population in Britain being on the North Yorkshire Moors, where the heather is managed by burning. Specimens dated from 1910 to 1915, from Drumpellier, Coatbridge, can be found in many entomological collections throughout Britain. These were mainly supplied by W.J. M'Leod, who, according to Balfour-Browne (1958), visited the site along with the original discoverer, G.A. Brown, and Anderson Fergusson in 1911. The near extinction of this species might be related to the loss of steam power, which would have ensured frequent burning of moorland neighbouring railways.

Macroplea appendiculata **(Panzer)** Most reed beetles have showy adults living above the water on emergent vegetation, in particular reeds and bur-reeds: their larvae, like those of the Noterus, depend on aerenchyma of aquatic plants for their air supply. Members of the genus *Macroplea* are amongst the most aquatic of all beetles, living below the water in all stages of the life-cycle unlike the majority of beetles, which pupate out of the water. The sole record of *M. appendiculata* stems from another specimen in Professor Crowson's collection, taken by his wife Betty in Loch Libo, Renfrewshire on 29 April 1967. *M. appendiculata* has as its host plants alternate water-milfoil (*Myriophyllum alterniflorum*) and fennel pondweed (*Potamogeton pectinatus*). According to Monahan and Caffrey (1996), working in Irish canals, this species prefers fennel pondweed when both potential hosts are available. Further attempts to find the *Macroplea* in Loch Libo have been unsuccessful, and the fennel pondweed, which was plentiful up to 2004, could not be found in 2008, possibly because of eutrophication. *Macroplea* appears to have been lost from Milton Loch, Kirkcudbrightshire, where it was abundant in 1996, and Loch Leven, Fife, where it was found in 1933: these lochs have suffered from algal blooms that would have destroyed suitable host plants.

Erirhinus aethiops **(Fab.)** This is a relatively large (5-7 mm long) black and shining weevil that looks as if it may have fallen in the water by accident when caught in the pond net. It lives on bur-reed (*Sparganium erectum*) and some sedges. Morris (2002) noted that it is usually rare and found north from north-east Yorkshire, though not in northern Scotland or on any of the islands. Pitfall trapping on exposed riverine sediment has established its presence in Wester Ross, Morayshire and East Inverness-shire (Eyre *et al.* 2000). Crowson (1971) recorded it from Loch Libo, where the author found it again on 31 May 2008.

THE 2010 SURVEY

The author's 2010 survey of ponds and similar habitats covered 37 sites generating 426 records of 76 species (Table 2), adding six species to the overall list. In Table 1 the other two species recorded in 2010 were from Craig Macadam's survey, *Hygrotus nigrolineatus*, described above, and *Haliplus fulvus*.

Apart from the *Hygrotus nigrolineatus* two other species are rated as Nationally Scarce on a GB-wide basis in a recent analysis (Foster 2010). *Rhantus frontalis*, represented by one specimen at Cardowan, is known in Scotland elsewhere from Angus in 1933,

Ayrshire, most recently in 1911, Fife, most recently in 1961, Stirling and West Perthshire in the 19th Century, West Lothian in 1985, and since 2005 along the Solway coast. Earlier records for the vice-county of Lanarkshire are by Magnus Sinclair and the author from Carstairs Kames (NS957472) on 8 April 1977 and by the author from Coalburn (NS8035) on 25 May 1981. The Kames provided a more typical habitat for this species, sparsely vegetated water over sand, than the new Glasgow site in a shaded tussock fen. This species overwinters out of the water (Galewski 1963) and probably flies to seek ponds suitable for breeding in the spring. The other Nationally Scarce species, *Helophorus granularis*, was common in the marsh where *R. frontalis* occurred. This is a species of "vernal swamps" (see Balfour-Browne 1958) and occurs, scattered across the British Isles, in the micropterous form *ytenensis* Sharp, the wings of which are reduced in size but possibly not entirely incapable of flight.

On the basis of these GB-nationally Scarce species the marsh at Cardowan rates as the site with the greatest conservation status in the survey. A system that assesses conservation quality of the basis of all species present was developed by Foster & Eyre (1992). It was based on counts of ten km square records converted to scores in a geometric series from1 for the commonest species, then 2, 4, 8...etc. up to the rarest species. The scores for southern Scotland used by Foster & Eyre (1992) are out-of-date, being based on considerably less records than are currently available and on a more limited suite of species than is currently recorded. New scores were developed (Table 2) based on counts of each species in the twenty 10 km squares of the search area used for Glasgow as available in the national recording scheme data-base, supplemented by records from the Chrysomelidae atlas (Cox 2007). These counts were used to assign each species a score from 1 to 5 on an arithmetic scale (1, 2, 4, 8, 16 if geometric) that then could be used to produce an aggregate quality score and a mean quality score for each site. The mean score should be more reliable than the aggregate score or the total number of species as it reduces the impact of variable recording effort.

Sites in Table 2 are ranked in order of the mean quality score. Bingham's Pond, beside the Pond Hotel on the Great Western Road, scores highest. This site, a typical Victorian Park pond with hard edges and many water fowl, has been improved by planting vegetation from Frankfield Loch and other Glaswegian sites (pers. comm. Sheila Russell). These plantings may have contributed the reed beetles that have raised the site's score. The second highest site is one of the few areas of seepage encountered, in this case the outflow of a balancing lagoon of the M77 at St. Martin's. The site with the greatest number of species, a pool behind the Phoenix Industrial Estate near to Glasgow Airport, scored third highest. This pool would appear to man-made in that it is formed by subsidence. Even the lowest scoring site, a peat ditch on Lenzie Moss, has one species of interest, *Hydroporus tristis*, but this and the other species present are characteristic of acid water that is still common around Glasgow.

DISCUSSION

There are many species of water beetle in and around Glasgow, their habitat range is diverse, and some species are in decline if not locally extinct whilst others are increasing. Declining species are associated mainly with peat, with running water and with exposed lake shores.

Pond species are generally doing well and do not require further conservation activity except that pond creation generates public interest and stewardship. The instant gratification of building a new pond cannot be denied! However, conservation activists are urged to avoid damage to existing temporary marsh systems in this process as many beetles require both vegetation cover and the periodic drought to eliminate predatory fish. Moving vegetation locally to soften the hard edge of a typical park pond has proved effective at Bingham's Pond, introducing host plants for showy beetles and providing marginal refugia for others.

Peatlands still exist in quantity around Glasgow despite the industrialisation and urbanisation of the area. The species dependent on a peat substratum will be the next to disappear unless the loss of peat is halted, preferably by flooding - so there is still scope for large scale pond creation. Land developments such as out-of-town shopping malls and golf courses, and the tidying up of brownfield sites just for the sake of tidying up could cause more damage than the industries from which the city grew.

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	Last record	No. 10 km squares	Quality score
Suborder Adephaga			
GYRINIDAE			
Gyrinus aeratus Stephens	2008	1	5
Gyrinus caspius Ménétriés	1913	2	4
Gyrinus marinus Gyllenhal	1915	3	4
Gyrinus minutus Fab.	1976	3	4
Gyrinus substriatus Stephens	2010	13	2
Orectochilus villosus (Müller)	1987	3	4
HALIPLIDAE			
Brychius elevatus (Panzer)	1910	3	4
Haliplus confinis Stephens	2010	7	3
Haliplus flavicollis Sturm	2010	7	3
Haliplus fluviatilis Aubé	1983	6	3
Haliplus fulvus (Fab.)	2010	11	2
Haliplus immaculatus Gerhardt	2010	6	3
Haliplus lineatocollis (Marsham)	2010	13	2
Haliplus lineolatus Mannerheim	2004	9	2
Haliplus obliquus (Fab.)	2010	1	5
Haliplus ruficollis (De Geer)	2010	14	2
Haliplus sibiricus Motschulsky	2010	14	2
NOTERIDAE			
Noterus clavicornis (De Geer)	2010	6	3
DYTISCIDAE			
Agabus affinis (Paykull)	2010	7	3
Agabus arcticus (Paykull)	1976	6	3
Agabus biguttatus (Olivier)	1932	5	3
Agabus bipustulatus (L.)	2010	19	1
Agabus congener (Thunberg)	2010	6	3
Agabus guttatus (Paykull)	1989	8	2
Agabus labiatus (Brahm)	1910	3	4
Agabus nebulosus (Forster)	2010	7	3
Agabus paludosus (Fab.)	2010	8	2
Agabus sturmii (Gyllenhal)	2010	15	2
Agabus unguicularis (Thomson)	2010	6	3
Ilybius aenescens Thomson	1974	2	4
Ilybius ater (De Geer)	2010	9	2
Ilybius fuliginosus (Fab.)	2010	15	2
Ilybius guttiger (Gyllenhal)	2010	5	3
Ilybius montanus (Stephens)	2010	6	3
Platambus maculatus (L.)	2008	9	2
Colymbetes fuscus (L.)	2010	13	2
Rhantus exsoletus (Forster)	2010	12	2
Rhantus frontalis (Marsham)	2010	2	4
Rhantus suturalis (Macleay)	2010	2	4
Rhantus suturellus (Harris)	1976	4	3
Acilius canaliculatus (Nicolai)	1992	5	3
Acilius sulcatus (L.)	2010	6	3
Dytiscus marginalis L.	2010	10	2
Dytiscus semisulcatus Müller	2000	8	2
Graptodytes pictus (Fab.)	1980	3	4
Hydroporus angustatus Sturm	2010	11	2
Hydroporus discretus Fairmaire	2010	7	3
Hydroporus erythrocephalus (L.)	2010	12	2
Hydroporus ferrugineus Stephens	1957	4	3
Hydroporus gyllenhalii Schiödte	2010	18	1
Hydroporus incognitus Sharp	2010	13	2
Hydroporus longicornis Sharp	1990	4	3
Hydroporus melanarius Sturm	1998	5	3
Hydroporus memnonius Nicolai	2010	13	2
Hydroporus morio Aubé	1989	7	3
Hydroporus nigrita (Fab.)	2010	12	2

Hydroporus obscurus Sturm	2010	6	3
Hydroporus obsoletus Aubé	1968	1	5
Hydroporus palustris (L.)	2010	17	1
Hydroporus planus (Fab.)	2010	13	2
Hydroporus pubescens (Gyllenhal)	2010	19	1
Hydroporus rufifrons (Müller)	1853	1	5
Hydroporus striola (Gyllenhal)	2010	13	2
Hydroporus tessellatus Drapiez	2000	1	5
Hydroporus tristis (Paykull)	2010	11	2
Hydroporus umbrosus (Gyllenhal)	2010	12	2
Nebrioporus assimilis (Paykull)	2004	11	2
Nebrioporus elegans (Panzer)	2004	12	2
Oreodytes davisii (Curtis)	1974	4	3
Oreodytes sanmarkii (Sahlberg)	2008	9	2
Oreodytes septentrionalis (Gyllenhal)	1987	9	2
Stictonectes lepidus (Olivier)	1910	2	4
Stictotarsus duodecimpustulatus (Fab.)	1984	10	2
Hygrotus confluens (Fab.)	1999	4	3
Hygrotus impressopunctatus (Schaller)	2010	4	3
Hygrotus inaequalis (Fab.)	2010	14	2
Hygrotus nigrolineatus (von Steven)	2010	1	5
Hygrotus novemlineatus (Stephens)	1911	2	4
Hyphydrus ovatus (L.)	2010	6	3
Laccophilus minutus (L.)	2010	5	3
Suborder Polyphaga			
HELOPHORIDAE			
Helophorus aequalis Thomson	2010	13	2
Helophorus arvernicus Mulsant	2008	4	3
Helophorus brevipalpis Bedel	2010	16	1
Helophorus flavipes Fab.	2010	13	2
Helophorus grandis Illiger	2010	11	2
Helophorus granularis (L.)	2010	3	4
Helophorus griseus Herbst	2010	1	5
Helophorus minutus Fab.	2010	9	2
Helophorus obscurus Mulsant	2010	8	2
Helophorus tuberculatus Gyllenhal	1915	1	5
HYDROCHIDAE			
Hydrochus brevis (Herbst)	1853	1	5
HYDROPHILIDAE			
Hydrophilinae			
Anacaena globulus (Paykull)	2010	19	1
Anacaena lutescens (Stephens)	2010	7	3
Chaetarthria seminulum s. lat.	1987	2	4
Enochrus coarctatus (Gredler)	2010	2	4
Hydrobius fuscipes (L.)	2010	15	2
Laccobius bipunctatus (Fab.)	2010	13	2
Laccobius colon (Stephens)	2010	3	4
Laccobius minutus (L.)	2010	4	3
Laccobius striatulus (Fab.)	1983	2	4
Sphaeridiinae			
Coelostoma orbiculare (Fab.)	1989	5	3
Cercyon marinus Thomson	2010	3	4
Cercyon ustulatus (Preyssler)	1985	1	5
HYDRAENIDAE			
Hydraena britteni Joy	2000	3	4
Hydraena gracilis Germar	2008	2	4
Hydraena nigrita Germar	1983	1	5
Hydraena riparia Kugelann	2010	13	2
Limnebius nitidus (Marsham)	1919	1	5
Limnebius truncatellus (Thunberg)	2010	14	2
Enicocerus exsculptus (Germar)	1987	3	4
Ochthebius dilatatus Stephens	2010	2	4

Ochthebius minimus (Fab.)	2010	2	4
SCIRTIDAE			
Microcara testacea (L.)	1999	1	5
Cyphon hilaris Nyholm	1999	1	5
Cyphon padi (L.)	2000	1	5
Cyphon variabilis (Thunberg)	2010	4	3
ELMIDAE			
Elmis aenea (Müller)	2008	5	3
Esolus parallelepipedus (Müller)	1987	2	4
Limnius volckmari (Panzer)	1990	5	3
Oulimnius tuberculatus (Müller)	1987	4	3
Riolus cupreus (Müller)	1987	2	4
Riolus subviolaceus (Müller)	2008	1	5
HETEROCERIDAE			
Heterocerus marginatus (Fab.)	1853	1	5
COCCINELLIDAE			
Coccidula rufa (Herbst)	2010	2	4
CHRYSOMELIDAE			
Plateumaris discolor (Panzer)	2010	4	3
Plateumaris sericea (L.)	2010	2	4
Donacia obscura Gyllenhal	1979	1	5
Donacia simplex Fab.	2010	1	5
Donacia versicolorea (Brahm).	1992	2	4
Donacia vulgaris Zschach	2010	2	4
Macroplea appendiculata (Panzer)	1967	1	5
Galerucella nymphaeae (L.)	2010	4	3
Hydrothassa marginella (L.)	2010	2	4
Phaedon armoraciae (L.)	2010	2	4
Phaedon cochleariae (Fab.)	2010	1	5
Prasocuris phellandrii (L.)	2010	5	3
CURCULIONIDAE			
Phytobius leucogaster (Marsham)	1994	2	4
Bagous alismatis (Marsham)	1900	2	4
ERIRHINIDAE			
Erirhinus aethiops (Fab.)	2008	2	4
Notaris acridulus (L.)	1901	4	3
Grypus equiseti (Fab.)	1901	1	5

Table 1. Water beetles recorded in and around Glasgow.

National grid reference	Site	VC	Date	No. spp.	AQS	MQS	Noteworthy spp.
NS55436811	Bingham's Pond	99	5 June	15	42	2.8	*Haliplus confinis, Donacia simple, D. vulgaris*
NS50495149	M77 Mearns box	76	12 May	5	13	2.6	*Hydrothassa marginella*
NS45286466	Phoenix Industrial Estate	76	24 April	24	61	2.5	*Phaedon cochleariae*
NS64857181	Lenzie Moss 2	99	10 April	10	24	2.4	*Agabus congener*
NS6720672	Gartloch Pool	77	5 June	17	40	2.4	*Haliplus confinis, Cercyon marinus*
NS707684	Gartcosh 4	77	20 March	15	35	2.3	*Acilius sulcatus, Agabus unguicularis*
NS651673	Cardowan 1	77	27 March	19	43	2.3	*Rhantus suturalis*
NS70576838	Gartcosh 6	77	5 April	15	34	2.3	*Haliplus confinis, H. obliquus*
NS4566160	Durrockstock pond	76	1 May	6	14	2.3	
NS654674	Cardowan 2	77	27 March	16	35	2.2	*Rhantus frontalis, Helophorus granularis*
NS55336220	Pollok Country Park, marsh	77	4 May	5	11	2.2	
NS62806838	Robroyston Park 2	77	17 July	17	38	2.2	*Phaedon armoraciae*
NS62776805	Robroyston Park 1	77	10 April	15	32	2.1	
NS50495147	M77 Mearns box	76	12 May	19	40	2.1	*Ilybius guttiger, Phaedon armoraciae*
NS707684	Gartcosh 3	77	20 March	12	24	2.0	*Hydroporus tristis*
NS653674	Cardowan 3	77	27 March	8	16	2.0	
NS52775930	Darnley Mill	76	1 May	12	24	2.0	
NS60576568	Cathkin Marsh 2	77	1 May	6	12	2.0	
NS60325791	Cathkin Marsh 3	77	1 May	16	32	2.0	
NS707685	Gartcosh 5	77	20 March	17	33	1.9	*Enochrus coarctatus*
NS43926568	Linwood Moss 2	76	24 April	14	27	1.9	*Ilybius guttiger*
NS51725274	M77 Mearns box	76	12 May	17	33	1.9	
NS705682	Gartcosh 1	77	20 March	13	24	1.8	
NS706687	Gartcosh 2	77	20 March	8	14	1.8	*Ochthebius dilatatus*
NS52195380	M77 Junction 5	76	12 May	14	25	1.8	
NS54795411	Titwood	76	12 May	12	21	1.8	
NS603722	Wilderness Plantation 1	99	5 April	3	5	1.7	
NS63466936	Robroyston Road	77	10 April	11	19	1.7	
NS55336220	Pollok Country Park, The Glade	77	4 May	3	5	1.7	
NS52225375	M77 Junction 5	76	12 May	11	19	1.7	
NS54565429	Titwood	76	12 May	7	12	1.7	
NS43656600	Linwood Moss 1	76	24 April	16	26	1.6	
NS55336220	Pollok Country Park, main pond	77	4 May	7	11	1.6	
NS601721	Wilderness Plantation 3	99	5 April	5	8	1.6	
NS60576568	Cathkin Marsh 1	77	1 May	4	6	1.5	
NS602721	Wilderness Plantation 2	99	5 April	2	3	1.5	
NS64787171	Lenzie Moss 1	99	10 April	6	8	1.3	*Hydroporus tristis*

Table 2. Summary of the 2010 survey. The vice-counties (vc) are 76 Renfrewshire, 77 Lanarkshire, and 99 Dunbartonshire. AQS is the aggregate quality score, i.e. the sum of all the species quality scores. MQS is the mean quality score, the average quality score value per species.

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Urban Biodiversity: Successes and Challenges: Clydebank as a hotspot for the common pill woodlouse *Armadillidium vulgare*

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ABSTRACT

In Scotland, the common pill woodlouse is at the Northern edge of its range. On the east coast it extends as far north as Johnshaven. Until a recent discovery in Helensburgh, the northernmost location in the west was Clydebank, where two sites were discovered by Futter (1998). An additional four sites have since been discovered, which is an unusual degree of clustering. Five of the six Clydebank sites are alongside railways. Consideration is given to factors permitting the species to arrive, survive and thrive in railway-side sites, and in Clydebank.

THE COMMON PILL WOODLOUSE IN SCOTLAND

The common pill woodlouse *Armadillidium vulgare* is the most widespread of seven native British species in the family Armadilliidae, hence the addition of "common" to its traditional vernacular name. It is one of the most common of all woodlouse species in southern Britain, but in Scotland it is more sparsely distributed and at the edge of its range. The nature of its Scottish distribution has become more clear as recording coverage has improved. The first published atlas of woodlice in Britain and Ireland (Harding & Sutton, 1985) showed three groupings of records: on the east coast as far north as Tayside; on the Solway coast; and inland among horticultural nursery sites in the Clyde valley between Rutherglen and Lesmahagow (Harding, Collis & Collis, 1980). There was just one west coast record, from Troon Station by J. Naden in 1976.

By the time data were compiled for a new atlas (Gregory, 2009), increased recording effort had resulted in a good number of additional records, including some published in *The Glasgow Naturalist* (Stirling, 1995; Futter, 1998) and records from a field meeting of the British Myriapod

and Isopod Group in Ayrshire in 2006 (Collis, 2007), plus a number of additional records by the author.

Comparison of the two atlases makes it clear that the difference in numbers of records between the east and west coasts in Harding and Sutton's atlas was partly an artefact of recording effort. However, the tendency for the species to extend further north in the east than in the west seems likely to be real, with a 2005 record from as far north as Johnshaven in the east (Davidson, 2010). In the west, the northernmost locations shown in the 2009 atlas were Futter's (1998) two sites in Clydebank, though in May 2009 the author found a site a little further north in Helensburgh, NS303820, at the shore end of a footpath from East Clyde Street.

Gregory's 2009 atlas also confirms that, in Scotland, the distribution of the pill woodlouse is predominantly coastal. Many of the coastal sites are on, or very close to the shoreline, which might be considered it's primary natural habitat in most of Scotland. However, care is needed in this respect. The record from Johnshaven was among builders rubble deposited above a shingle beach (Davidson, 2010). The Helensburgh shoreline site could equally well be regarded as a suburban site with a high potential for the introduction of small invertebrates among rubble, garden waste, etc., dumped on the shoreline. There is a strikingly similar suburban shoreline site at Boathouse Road, Largs, NS197607. A site at Fairlie, NS207541 could also be classified as suburban shoreline, but with the further complication of a nearby wholly artificial coastline constructed in the 1970s for the Hunterston deep-water ore and coal terminal. A railway line followed the artificial coastline to service a now-dismantled iron ore reduction plant. Much of the material for the construction project was obtained locally, from Biglees Quarry and Campbeltown Farm (http://www.hunterston.eu/oreterminal), but doubtless other materials were brought in from further afield.

CLYDEBANK SITES

The first records of the pill woodlouse in Clydebank were by Futter (1988). In the period 1995-1997, she located specimens in a suburban garden in Parkhall Road, NS488718, and around a disused band hall on Second Avenue, NS495710. I visited these two locations in June 2007 and found the species in large numbers (>100) around the band hall and also beside the church close-by on Second Avenue. On Parkhall Road, instead of searching gardens, I found the species in small numbers in public shrubbery areas at NS489718 - close to Futter's location.

Two features of the band hall site are that it is immediately adjacent to a railway line and, like much of Clydebank, it is on a south facing slope. The pill woodlouse is believed to favour sunny locations; unusually for woodlice it is sometimes found in full sunlight (Gregory, 2009). The band hall is in a very sunny location, elevated above the railway line on the other side of which the land falls away sharply to the south. Having found pill woodlice associated with railways in England and Wales, and mindful of Cawley's (1996) observations in Ireland, as and when opportunities arose I searched railway-side sites elsewhere in Clydebank. Non-railway habitats were not searched so thoroughly.

Fig. 1. Sketch map of Clydebank sites for the common pill woodlouse: 1 Parkhall Road, NS488718; 2 Second Avenue (derelict band hall) NS495710; 3 Argyle Road railway bridge, NS501705; 4 John Knox Street NS504694; 5 Cable Depot Road (abandoned docks line) NS490705; 6 Clydebank Public Park/Dalmuir Station NS484714.

In May 2008 I found the species among rubbish at the base of railings separating railway land from mown grass at the north-east corner of Argyle Road railway bridge, NS501705. Like the band hall site, this is on the Singer line. Subsequently, I discovered a site on the Yoker line (NS504694, November 2009), among rubble at the base of a brick wall separating railway land from the site of a demolished building, accessible from John Knox Street.

The Yoker and Singer lines converge at Dalmuir Station. Here too I found pill woodlice among rubble at the base of the railway-side fence where it is accessible from the southern corner of Clydebank Public Park (NS484714, June 2010). In the park, I also found it a short distance away from the railway, where the Park borders the western end of Regent Street (NS484715). I was unable to find this species in a search of the glasshouses and their immediate surroundings at the western-most corner of the Park (NS480716), even though glasshouses and horticultural areas are often favoured by the species. It's absence there cannot easily be explained by an overuse of pesticides since I easily found the woodlice *Oniscis asellus, Philoscia muscorum, Porcellio scaber, Porcellio spinicornis* and *Trichoniscus pusillus* agg. at this location. Of course, pill woodlice may yet be found there.

In addition to the Singer and Yoker branches of the railway network through Clydebank, there are also the remains of branch lines to the docks. I found pill woodlice at the foot of the embankment of one such disused line (NS490705, June 2010), accessed from an abandoned industrial site on Cable Depot Road.

Conservatively, if we consider the two closely adjacent sites in Clydebank Public Park (Dalmuir Station and end of Regent Street) as one, and similarly with the two Parkhall Road sites (suburban garden and public shrubbery), there are now six known sites for pill woodlice in Clydebank (Fig. 1). This is a remarkable cluster of sites within a small area.

There is a similar density of known sites in the Salisbury Crags/Holyrood Park/Duddingston area of Edinburgh. Not very far from this cluster, on 16/08/2010 I was able to locate three new sites along a short stretch of railway line: at the pedestrian underpass in the University sports ground at Peffermill, (NT280712); on the cycle path beside the railway at Bingham (NT297721); and by the road bridge over the railway at the south-west corner of Jewel Park (NT304721). I am also aware of two railway-side sites in Edinburgh located by the late Bob Saville in May 1994, at (NT219724) and (NT226718).

For reasons of more ready access from my home in Bute, I have spent far more time on a greater number of different dates searching the Gourock-Greenock-Port Glasgow area, including many railway-side sites, and have not yet found any pill woodlice. It is probably significant that with the ground rising steeply to the south, this area is much less sunny than south-facing Clydebank. It is also possible to make comparisons with central Glasgow where I spent much time looking for woodlice in the 1970s (Collis & Collis, 1978) though I did not examine many railway-side sites. I did not find any pill woodlice though I was brought specimens from a now abandoned nursery at Westfield Avenue, Rutherglen, (NS605612).

DISCUSSION

How might the Clydebank cluster of sites be explained? To understand the distribution of a species that is not ubiquitous in an area, we need to consider how it might arrive at new sites, what conditions are needed in order for the arrivals to breed sufficiently well for the colony to survive, and why the colony is able to thrive so as to become numerous enough that it will persist through occasional severe conditions.

For medium-sized flightless invertebrates like pill woodlice, arrival presumably requires it to be carried to a new site, conceivably in flood debris or driftwood, but more likely by inadvertent human transport. In the latter case, there will be a bias toward them arriving in habitats associated with human activity. It is well understood that many species of woodlice are particularly likely to be found in synanthropic sites, but it is not straightforward to disentangle the relative contributions of anthropic factors for arrival and for survival.

One strong possibility for how they might arrive at locations throughout greater Glasgow and Clyde area is through the movement of agricultural and horticultural produce. Prior to the dominance of motorised transport, the movement of fodder and bedding for horses is likely to have been a significant factor in the transport of invertebrates in urban areas. Several species of woodlice, including *Armadillidium vulgare*, are known to flourish in horticultural nurseries. They are still present at two sites in Rothesay where there were once extensive commercial glasshouses (Collis & Collis, 2008), and the species is known from various sites with horticultural connections, including the nursery in Rutherglen, mentioned above, several nursery sites in the Clyde valley (Harding, Collis & Collis, 1980), Culzean Castle gardens and the 'gardens' area of the agricultural college site at Auchincruive (Collis, 2007).

It is well understood that 'hothouse' alien woodlice (Gregory, 2009) are transported with plant material between botanic gardens, and there can be little doubt that this also applies to commonplace plants used in domestic gardens and allotments. Maybe the Parkhall Road colony of pill woodlice became established in this way. It was once common for allotments to be established beside railways, but it is not clear whether this applies to any of the railway side pill woodlouse sites in Clydebank. There is also the potential for transport in garden waste discarded onto areas that are regarded as "waste ground". Garden waste can include rubble from paths and rockeries, etc., as well as plant material and soil. It is often seen dumped on railway land, although this was not particularly noticeable at the Clydebank sites. As noted in the introduction, garden waste is also dumped on suburban shorelines, and on rural shorelines too, especially near roadside lay-bys.

There is also a strong probability that woodlice, including *A.vulgare*, are transported in various construction materials including quarried stone and aggregates, especially if the material had some calcareous content, or topsoil (Cawley, 1996). Other possibilities are timber, bricks, concrete fabrications, pipes, and general steelwork, especially if such items have been stored in the open for long enough for them to have become colonised by woodlice. Railway track is normally bedded on hard rock chips, which are typically non-calcareous, but I have information that it is not unusual for the foundations to be formed from softer calcareous rock. Depending on the source location, it is easy to envisage lime-loving invertebrates such as pill woodlice being introduced in such material. In addition to the basic bed of the track, a wide variety of materials are involved with railway-associated structures.

Irrespective of how woodlice got to the railway-side sites, we still need to understand why they have survived and thrived, especially, it seems, in railway-side sites in Clydebank. Even if there is no calcareous rock in the foundation of the trackway, there is likely to be an ample supply of lime in mortared walls and various line-side structures. Pill woodlice are much less tolerant of wet conditions than other woodlice, and the open well-

drained substrate would suit them well, with relatively large interstices allowing this bulky species easy movement through spaces to find microsites that are suitable in a variety of climatic conditions. Clydebank has the added advantage of a sunny south-facing aspect.

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Urban Biodiversity: Sucesses and Challanges: Urban tern ecology: common terns in Leith Docks

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The Imperial Dock Lock, a disused lock wall in Leith Docks, Edinburgh, supports the largest common tern (*Sterna hirundo*) colony in Scotland and was designated as a Special Protection Area (SPA) for the species in 2004. The SPA lies in a continually changing operational port and the port owners are keen to understand more about the terns. Analysis of long-term count data suggests that colonisation of this urban environment occurred as a result of relocation from natural islands in the Firth of Forth over the past few decades, in particular Inchmickery, which was formerly a regional stronghold for the species, but was abandoned possibly due to high numbers of gulls. Field work was performed at the colony during the breeding seasons of 2009 and 2010. Foraging studies showed that terns fed primarily in the Firth of Forth rather than within the docks, and their diet consisted mostly of clupeids, but also sandeels and small gadoids. Predation of chicks by herring gulls (*Larus argentatus*) and lesser black-backed gulls (*L. fuscus*) was observed in both seasons, despite which, high numbers of chicks fledged from the colony. Observations and preliminary experiments on the terns' sensitivity to disturbance at the eolony indicated that the birds are tolerant of routine human activities in the docks and that they have become well habituated to breeding in this urban environment. The results of this study combined with continued monitioring will be useful for the conservation of this SPA.

Urban Biodiversity: Successes and Challenges: Human perceptions towards peri-urban deer in Central Scotland

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Red deer (*Cervus elaphus)* have been successfully breeding in the Scottish highlands for centuries, and many people have a classic association of herds of deer roaming over the vast expanding Scottish hills. However, today species such as roe deer (*Capreolus capreolus*) are increasingly being seen in and around Scotland's Central Belt, produeing a very different human perception of deer than in the Scottish Highlands. Roe deer bring benefits and impacts to peri-urban areas (communities consisting of urban and rural components) within the Central Belt. It is not yet known peoples' perception towards deer in more urbanised communities, and whether they perceive deer to be beneficial to the local environment or a hindrance.

In the UK there is an estimated 316,000 red deer, 300,000 roe deer, 128,000 fallow (*Dama dama*), 128,000 muntjac (*Muntiacus reevesi*) and 26,600 sika (*Cervus nippon*) and 2100 Chinese water deer (*Hydropotes*

inermis) (Mammal Society, 2012). Deer abundance for all red, roe, fallow, sika and muntjac deer species has been recorded in the Scottish Highlands for 10 consecutive years, (2000-2010) indicating deer densities to be as high as 30 per km^2 in the Perthshire area, just north of Pitlochry and in the north west area of Drumnadrochit (SNH, 2012). Furthermore the lowest deer density of 1-5 deer per km^2 stretches from Inveruglas in central Scotland to Cape Wrath in the north and from the Outer Hebrides to the west side of Banchory (SNH, 2012). Red deer were recorded throughout the Scottish Highlands, though not recorded in the Central Belt and regions to the South East of Scotland. (NBN, 2012). Roe deer are more widely distributed than red and are found throughout the whole of Scotland, except from the Shetland islands and the Outer Hebrides. (NBN, 2012). Sika deer are more widely distributed than fallow deer in Scotland, but less so than red or roe, found widely distributed in the North West Highlands of Scotland and in Central Southern Scotland (NBN, 2012). Fallow deer were recorded in over 110 10 km^2 in Scotland with a much more sparse distribution compared with red and roe deer with pockets of higher densities in the west and east central Highlands, and in South West Scotland. (NBN, 2012). Muntjac deer were noted in 15 10 km^2 regions in Scotland sparsely distributed throughout Scotland (NBN, 2012). Deer abundance in these peri-urban communities is also not well known. In order to address some of these questions Forest Research on behalf of the Deer Commission for Scotland was asked to undertake a social and ecological study to: A) Examine if deer presence was being felt in peri-urban communities by members of local communities in Central Scotland and to highlight the benefits of possible deer presence, B) Undertake an ecological study on deer density within Central Scotland ascertaining whether deer density figures tied in with peoples' experience of deer presence in their local community.

To complete both studies two case study areas were set up; Ravenscraig in the West of Central Scotland and Linlithgow in the East of Central Scotland. The two areas were chosen for their mosaic of urban and rural areas and were seen as classic peri-urban environments.

For study A, 7 focus groups were conducted in total between each case study area (6 in Ravenscraig and 1 in Linlithgow) to examine what people in the local community thought about deer in their local area, and 3 manager focus groups were conducted (2 in Ravenscraig and 1 in Linlithgow) to examine what professional deer managers thought about deer in Central Scotland. 'Deer manager' in this case refers to people who have a higher level of knowledge about deer management than the general public, and relates to professional deer stalkers, forestry officials and members of conservation groups. At each focus group a series of slides were shown to participants, and a general introduction to each slide was talked about before the group engaged with the subject. Managers and community focus group structures were identical. To further facilitate study A, a questionnaire was sent out to local community groups ranging from allotment groups, to local sports associations. The questionnaire like the focus groups asked about local deer presence in their area and asked participants to rate deer management options in response to hypothetical deer management situations. In total 415 questionnaires were sent out and 154 were returned, giving the study a successful response rate of 37%.

For study B, night time thermal imaging of deer occurred along farm road transects in each case study area using a Pilkington Lite imager. See Dandy *et al.* (2009) for full survey methods. When deer were seen through the camera, the number of deer, the co-ordinates of their position and distance from the car guestimated, and noted down. The results were then placed in a statistical programme to generate density figures.

For the social study A the participants did show that deer were in their area agreeing with the general perception that deer are using peri-urban environments:

"It's made my day when I've seen them. .... It makes all the difference...Fantastic difference..." (Community Group 1)

"..it's nice to know that they are around. It just makes people feel more natural, a more natural environment." (Community Group 7)

The general feeling from the community focus groups was that deer did exist in the community but that they were not very prevalent, perhaps this relates to the roe deer's timid nature and being mainly active very early in the morning when most people are still asleep. In no way did any community focus group think that deer were overabundant in their community.

Study A also highlighted the benefits that deer bring to their community:

"If you catch sight of the deer, it means the environment is on a high because they're in the area. And if you're not getting good ecology and good feeding grounds they just move away, you see less and less of them.. it's letting you know that the environment and the ecology in the area is really good" (Community Group 6)

As well as bringing in a human wellbeing factor, deer in the local community were seen as a sign that the environment they were living in was healthy. Therefore deer presence was an indicator of living in a healthy green community which many residents see as a positive benefit to where they live. From the questionnaire participants were asked to rank statements in accordance to their preference to the question: 'If the number of deer in the area where you lived increased, which of the following would be the most important priorities?' Participants produced the following order of statements starting with the highest priority:

1. Preventing road-traffic accidents involving deer
2. Ensuring the welfare of individual deer
3. Maintaining the cultural value of deer in Scotland
4. (Joint) Preventing deer damaging local woodlands
4. (Joint) Preventing deer damaging gardens and other vulnerable sites
6. Making a living from deer through deer-watching tourism
7. Obtaining economic income from deer through sport shooting 'stalking'

From the ranking exercise the first statement indicated that if the local deer population was to increase, preventing direct physical road traffic accidents with deer would be the highest priority. This statement being first shows that the community would like to prevent the risk of a serious accident with deer as it is the only statement which contains a serious risk to humans of having deer in the local community. No other statements perceive such a high risk to humans in particular. It could be seen that the first statement protects humans and deer from risk. In the second statement, 'ensuring the welfare of individual deer' it shows that people in general have a high regard for deer welfare in their area, and would like to prevent harm being inflicted on local deer populations. The second statement's position correlates with the general findings from the focus groups that people enjoy seeing deer and therefore want to care for them in some way by looking after their welfare. Direct damage by deer seen in the two statements in joint 4th position shows that direct physical impacts by deer were not of a high concern for residents. Least concern was the statement relating to obtaining economic gain from a local deer population via sport shooting. This correlates with results from the focus groups that sport shooting was mainly only done in the Scottish Highlands and wouldn't be an activity by people in Central Scotland. A comment from the focus group was:

"I couldn't see them [tourists] coming here and saying 'while we are in Motherwell and Lanarkshire, we'll go and see deer'. But I would think they might think that way if they were heading for the Glencoe area for instance or above Stirling…" (Community Group 1)

Therefore it is perceived that no economic value would be practically obtained by local people if deer were sport hunted in their local community.

From study B it was found that deer in Linlithgow had a deer density estimate of $0.9km^2$ in open areas and $0.8\ km^{-2}$ in forested areas. Ravenscraig had a deer density estimate of $3.3km^{-2}$ in forested areas and $1.4\ km^{-2}$ in open areas. These density estimates are rough estimates as not all transects could be done due to access issues in 2009, but the vast majority were completed. Furthermore the estimates were taken from driving along farm roads at night and it can be assumed that not every deer can be seen from farm road positions. Roe deer were distinguished from other deer by their small to mid size and by the fact that they were seen in groups of about 2 or 3 individuals. The thermal imaging camera only showed a bright silouhette of deer so it was reliant on the observer to fully determine if the deer seen was roe. However local knowledge and experience of using the thermal imaging camera before helped to reduce identification bias. The results however show that deer densities are relatively low for both case study areas and show that Ravenscraig has a higher deer density than Linlithgow, and could be due to the Ravenscraig site having a higher sampling intensity with 188 km^2 sampled compared to 88 km^2 in Linlithgow. (This was in part due to snowfall preventing more sampling being undertaken in Linlithgow at time of survey). Overall the densities for each case study are in agreement with focus group findings that deer exist in the community but are not very commonly seen by residents.

The study shows through thermal imaging surveys, questionnaires and via focus groups that roe deer are penetrating into peri-urban environments within Central Scotland and this is the first study of its kind in Scotland. The density of deer is low in comparison to mean deer densities in the Scottish highlands that may be as great as $30km^{-2}$ (SNH, 2012), but the landscape and deer species (red deer) being different are contributing factors for this difference. The study also highlights the respect the general public have for deer, and the benefit deer have to the wellbeing of humans within peri-urban environments, as with most nature species. In relation to the theme of connecting communities and nature discussed at the Glasgow Natural History Society Conference on Urban Biodiversity, there were several plans to develop green corridors in urban environments to improve connectivity of nature. Such ideas were the Integrated Habitat Networks proposed by SNH, Woodlands In And Around Towns by the Forestry Commission, Living Waters project by Froglife and the importance of bings and brownfield sites were highlighted by the University of Edinburgh and Buglife respectively. These schemes would encourage deer and other species to move into and around urban and peri-urban environments. This may help to increase peoples' perceptions that they are living in a healthy environment because their local area is supporting species such as roe deer. Increasing deer populations in peri-urban environments may raise important management issues. If deer numbers were to increase substantially impacts such as deer vehicle collisions and damage to parks and gardens will need to be addressed. However from the focus groups and questionnaire no management was deemed necessary by residents as the deer population was seen as too low to justify any current management plans. Therefore deer in peri-urban environments at this moment in time present a positive factor if seen in local green spaces.

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Urban Biodiversity: Successes and Challenges: Epigeal invertebrate abundance and diversity on Yorkshire allotments

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ALLOTMENTS: FASCINATING HABITATS

After more than half a century of neglect and decline, allotments are on the brink of a great revival (Foley, 2004). Recent decades in particular have witnessed a growing demand for allotments, partly linked to the demand for healthy, pesticide-free food and an escape from the pressures of modern, busy urban lives. The image of traditional plot-holders e.g. retired men may be slowly changing. Allotment plots are inereasingly managed by young women and professional couples keen to grow organic crops or seek an eseape from the daily grind (Buckingham, 2005; pers obs). In parallel to the increased interest in the soeio-economic, health and recreational benefits of allotments, there is a growing interest in the biodiversity value of these unique mosaics of intensively managed habitat (Gilbert, 1991). However, to date there has been little published research which concentrates on them.

Marshall (2009) used a questionnaire-based survey to assess garden and allotment biodiversity and attitudes to it. He found that, among other things, having direct contact with plants and wild animals in a garden or allotment helped foster a wider interest in nature. Thus, allotments, because they typically involve a cross-section of a community, ean offer an ideal opportunity to engage people on an individual or community level and allow them to take a greater interest in their local wildlife.

The aims of our research were to test any variation in epigeal (ground-dwelling) invertebrate abundanee and diversity along an urban-rural gradient, in relation to any effects of allotment plot management styles i.e. traditional or wildlife-friendly.

GENERAL APPROACH

A questionnaire-based survey was used to determine plot-holder attitudes to allotment management styles and the importanee of wildlife on the sites. From these data, individual plots aeross allotment sites in east Yorkshire were identified to sample the epigeal invertebrates. In addition, plots were assigned as being either 'traditional' or 'wildlife-friendly' based on self-deelaration. A range of environmental data were eollected to determine the urban-rural gradient e.g. rural sites were likely to have a high percentage of surrounding farmland whilst urban sites were likely to have a high percentage of surrounding hard cover. These data were informed by the results of the Biodiversity in Urban Gardens in Sheffield (BUGS) project whieh examined, among other things, garden invertebrate biodiversity (Smith *et al.*, 2006 a,b). Three pitfall traps, pooled per plot, were used to sample invertebrate abundance and diversity in May and September 2006 on six plots from each of seven sampling sites chosen (N = 6 x 7 x 2 – 10 plots compromised/vandalized = 74) . These sites represented an urban-rural gradient and each site contained three 'traditionally' managed plots and three organic, wildlife-friendly plots, as identified from the questionnaires.

BIOLOGICAL DATA

Pitfall trapping resulted in the collection of 11,718 individual organisms; eight taxa were subject to further analysis. There was a signifieant difference in the mean number of individuals per allotment site (Fig 1). The rural Driffield allotment site contained significantly lower overall invertebrate abundance eompared to the Newland site in Hull city eentre, which had the highest abundanee. Although none of the other sites were statistically different from each other, there was a trend towards an increase in mean abundance moving towards the city centre.

Beetles (Coleoptera) constituted 37.95%, woodlice (Isopoda) 24.03% and spiders (Araneae), 16.93% of the catch respectively. Urban sites tended to be dominated by woodliee whilst beetles tended to be more eommon on some suburban and rural sites. The results for spiders and the other five taxa, whose abundance ranged between 0.73% - 8.96% of the total eatch, showed mixed abundanee across the urban-rural gradient (Fig 2).

With regard to overall invertebrate abundance in relation to management styles, the urban wildlife-friendly managed plots contained significantly higher abundance compared to all other plots, except the urban traditional plots. The latter, whilst not statistically significant, did not contain such high abundance as the urban wildlife plots. This therefore highlighted a trend towards increased abundance along the rural, suburban, urban gradient, especially on those plots managed in a wildlife-friendly way.

The effects of management style on individual taxa gave mixed results; different taxa dominated over differing management styles. Beetles were significantly more abundant on traditionally managed plots. In contrast, the woodlice, slugs and snails (Mollusca) were significantly more abundant on wildlife-friendly managed plots. Spiders, opilione, millipedes and centipedes (Myriapoda) showed little difference in abundance in relation to management style. The most biologically diverse plots were managed in a wildlife-friendly way, with the highest diversity found on a rural site at Driffield. Interestingly, this site also contained the lowest diversity on the traditionally managed plots.

DISCUSSION

This study has shown that there is considerable interest from allotment plot-holders in projects that recognize the value of "their" allotments. Whilst older men still dominate, there are an increasing number of community groups, younger families and especially women, taking on allotments. The latter are also more likely to place a higher value on the wildlife on their plots and sites, as shown by their commitment to manage their plots in an organic, wildlife-friendly way.

The epigeal invertebrate taxa on the seven allotment sites studied showed a significant variation in both abundance and diversity along an urban-rural gradient. In contrast to what may have been expected, the urban sites contained the highest abundance whilst the rural sites contained the lowest. Whist urban sites are likely to be subject to a higher range of anthropogenic pressures, each allotment site may be a small-scale biodiversity oasis, due partly to the laek of other suitable surrounding habitat patehes compared to rural areas.

The composition of the taxa found in the current study was similar to that of the BUGS studies mentioned above, but the actual proportions of some of the taxa were quite different. For example, Smith *et al.* (2006_b) found that the three most abundant taxa of the pitfall traps were woodlice (45%), beetles (25%) and slugs (19%) respectively, whilst in the current study they constituted 24%, 38% and 9% respectively. The most abundant taxa, the beetles, dominated the rural, and to lesser extent suburban, sites. The woodlice, however, dominated the urban sites, suggesting that they prefer synanthropic environments. In addition, spiders contributed 17% of the total eatch, compared to less than 5% in the BUGS study.

The reasons for these differences are likely to be many and require further exploration. However, in the case of the slugs, it is likely that this group would be very actively discouraged from allotments, due to their primary *raison d'être* as a means of growing food crops. Slug pellets were the most common pesticide used, as evidenced in the questionnaires, supporting this conclusion.

Whilst management style suggests no *overall* difference in total invertebrate abundance, the differences at geographic scale do appear to show some effect. The higher abundance found on the wildlife-friendly allotment plots in the city centre may be due to a skewed effect of the high number of woodlice on these plots, as discussed above.

Overall, the diversity of the taxa found suggests that allotments are valuable habitats for epigeal invertebrates. The highest invertebrate diversity, found at the rural Driffield wildlife-friendly plots, corresponds with their low abundance and requires further study to try and explain the reasons. The environmental data gathered suggests that the high proportion of farmland surrounding the allotment site may account for some of the variation. Species are likely to be able to disperse readily into the surrounding habitat, unlike the more constrained urban habitat patches.

FUTURE WORK

Further work is ongoing to identify the three most abundant taxa to species level from a rural, suburban and urban allotment site respectively. Additional analysis of the questionnaire data, environmental and biological data will be published separately in due course. This work will therefore provide some much-needed empirical data on the epigeal invertebrate communities present on Yorkshire allotments. This baseline information could then be used to explore further issues such as biological control methods or effects of climate change on crop growing on allotments.

CONCLUSIONS

The increase in popularity of allotments offers a great opportunity to study the wildlife benefits of such sites, particularly in urban areas where greenspace is at a premium. In order to advance these studies, it is important to engage with individual plot-holders.

The epigeal invertebrate taxa found on these allotments are similar to those found in garden studies, but the proportions of dominating taxa vary across the urban-rural gradient and with management styles. Abundance was higher on urban plots, especially wildlife-friendly managed ones, compared to both traditionally and wildlife-friendly managed plots on rural or suburban sites. Invertebrate diversity was highest on some wildlife-friendly rural plots, which also had low abundance. Future work will help identify the specific species present and provide further clues to their ecological role on allotment sites.

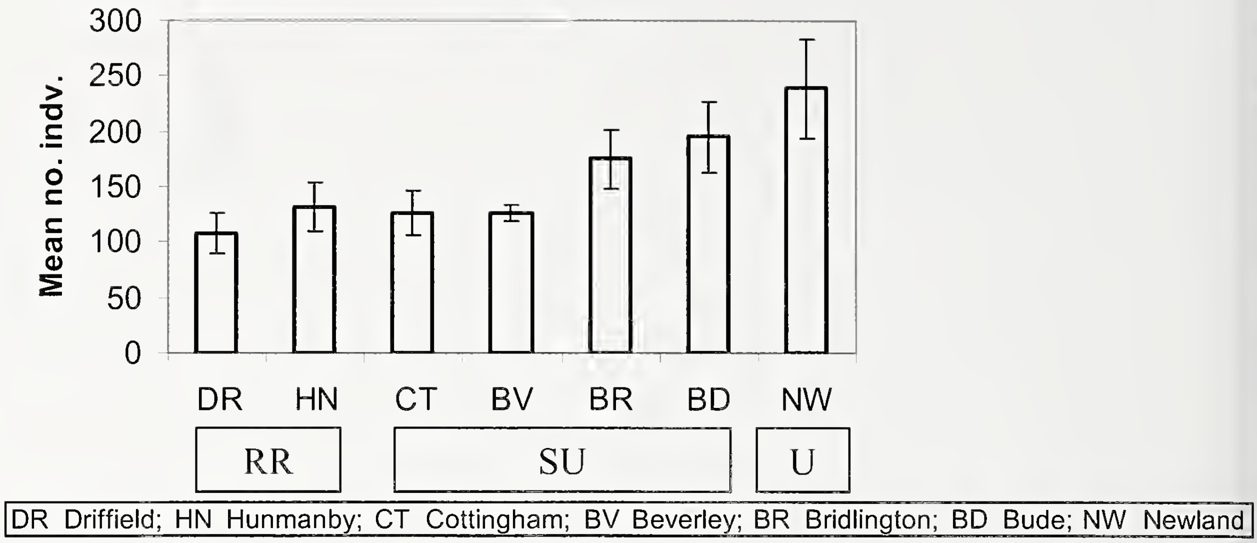

Fig. 1. Mean number of invertebrates per Yorkshire allotment site (± SE), based on individual plot totals (N=74), grouped per urban-rural gradient. (RR=rural; SU=suburban; UU=urban.)

Fig. 2. Total number of each invertebrate taxon from pitfall-traps on seven Yorkshire allotment sites.

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Urban Biodiversity: Successes and Challanges: Brownfields: oases of urban biodiversity

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ABSTRACT

Despite their potential to support biodiversity, a strong negative public image has been attached to brownfield sites, with the conservation of these sites therefore lagging behind other habitats. The inclusion of 'Open Mosaic Habitats on Previously Developed Land (OMHPDL)' as a UK Biodiversity Action Plan (UKBAP) priority habitat has however resulted in a renewed focus on brownfields as important wildlife habitats. The experiences of Buglife – The Invertebrate Conservation Trust in both the Thames Gateway and central Scotland have shown that brownfield sites can support many rare, scarce and UKBAP priority species, some of which are becoming increasingly reliant on such sites as their natural habitats come under threat.

INTRODUCTION

The industrial revolution starting in the eighteenth century transformed the scenery of our towns and countryside. Central Scotland was at the heart of this revolution and many heavy engineering works and iron founders were based there. With the demise of these industries across the country, their former premises have been left derelict. Many of these ex-industrial sites have since been reclaimed by nature through natural succession.

This rich industrial heritage of Scotland has resulted in over 10,000 hectares of land being listed as vacant or derelict. These brownfield sites can be incredibly important for biodiversity, often supporting nationally important populations of rare and endangered invertebrates, alongside other wildlife such as birds, reptiles, plants and lichens. With the loss of natural habitats in the wider countryside through agricultural intensification and development, wild areas within the urban environment have become crucial to the survival of many increasingly threatened species in the UK. As a result Open Mosaic Habitat on Previously Developed Land (OMHPDL) was recently included as a UKBAP priority habitat.

Brownfields are any site that have been altered by human activity and are currently not fully in use (CABE, 2006). They tend to be concentrated in urban and former industrial landscapes but also include quarries, spoil heaps, old railway lines and disused airfields (Allan et al. 1997; Bodsworth et al. 2005; Whitehouse, 2008; Riding et al. 2010). Brownfield sites provide linkages or 'stepping stones' between more natural areas of habitat and facilitate the movement and mixing of individuals in a less favourable urban setting. Lack of management of brownfields often creates an open mosaic of habitats such as species rich grassland, bare ground and early successional habitats (Key, 2000; Bodsworth et al. 2005; Harvey et al. 2008). This, combined with a low nutrient content of the soil which prevents fast growing species becoming dominant, provides a continuity of resources for invertebrates throughout the season (Harvey et al. 2008). In addition, a mosaic of habitats provides a home for a wide range of species and allows many to complete their life cycles within the same site (Bodsworth et al. 2005).

It has long been recognised that brownfields may have as many associated Red Data Book (RDB) and Nationally Searce invertebrate species as ancient woodlands (Jones, 2003). At least 194 invertebrate species of conservation importance, including 50 red data book and 131 nationally scarce species, have been recorded from brownfield sites in the UK. This includes 50% of rare solitary bees and wasps and 35% of rare ground beetles (Bodsworth et al. 2005). Brownfields also support a suite of UKBAP priority species. For example, the lack of management on brownfield sites often provides a secure area for breeding birds such as skylark (*Alauda arvensis*) and grey partridge (*Perdix perdix*), that are often absent from land under agricultural management. Many features identified at long abandoned industrial sites can no longer be found in the managed and over-farmed wider countryside or even in over-tidied parks (Bodsworth et al. 2005). Loss of natural habitat is causing many species, including bumblebees, beetles, butterflies and reptiles, to become increasingly reliant

on brownfield sites.

Despite their potential to support biodiversity a strong negative public image has been attached to brownfields due to lack of management and a perceived untidiness and they are increasingly threatened by development and landscaping (Key, 2000; Riding et al. 2010). Restoration of post-industrial sites into greenspace can destroy much of the existing wildlife interest through the importation of large quantities of topsoil and tree planting. Site restoration can also result in the loss of particular niches at brownfields which will have a knock on effect on the wildlife found at that site (Bodsworth et al. 2005). For example, the loss of bare ground at a site will affect thermophilic (warmth-loving) invertebrate species such as spiders and ground beetles as well as species such as mining bees and solitary wasps that nest in the ground (Key, 2000; English Nature, 2005; Whitehouse, 2008).

In 2007 Open Mosaic Habitat on Previously Developed Land was added to the list of priority habitats in the UK Biodiversity Action Plan (Maddock, 2008). To fit the UKBAP criteria for OMHPDL the site must be over 0.25 hectares in size and have a known history of disturbance (Table 1). In addition, there must also be a mosaic of vegetation on the site comprised of early successional communities and un-vegetated bare areas.

	Criteria
1.	The area of open mosaic habitat is at least 0.25 ha in size.
2.	Known history of disturbance at the site or evidence that soil has been removed or severely modified by previous use(s) of the site. Extraneous materials/substrates such as industrial spoil may have been added.
3.	The site contains some vegetation. This will comprise early successional communities consisting mainly of stress tolerant species (e.g. indicative of low nutrient status or drought). Early successional communities are composed of a) annuals or b) mosses/liverworts or c) lichens or d) ruderals or e) inundation species or f) open grassland or g) flower rich grassland or h) heathland.
4.	The site contains un-vegetated, loose bare substrate and pools may be present.
5.	The site shows spatial variation, forming a mosaic of one or more of the early successional communities a) – h) above (criterion 3) plus bare substrate, within 0.25 ha.

Table 1. Open mosaic habitat on previously developed land definition and criteria (Riding *et al.* 2010).

The conservation of brownfield sites has lagged behind other important habitats for plants and wildlife. The term brownfield was first used by the government in 1998 when they set a national target of 60 % of all new housing developments to be located on brownfield land (Bodsworth et al. 2005; Riding et al. 2010). In Scotland, the National Planning Framework aims to bring 'vacant and derelict land' back into productive use for housing, for economic purposes and to create attractive environments however there is potential for this vision to conflict with the conservation of Open Mosaic Habitats on Previously Developed Land OMHPDL and urban biodiversity.

BROWNFIELDS AND BUGLIFE

Buglife was one of the first conservation organisations to highlight the ongoing loss of brownfield habitats – and the serious consequences of this for biodiversity – and has been working to conserve brownfield wildlife since 2004. Buglife's flagship 'All of a Buzz in the Thames Gateway' project in southern England has mapped and assessed the biodiversity of over 1,000 brownfield sites. This study has identified that although as many as a third of all brownfield sites support high levels of biodiversity – in many cases significantly higher than surrounding 'greenfield' agricultural land – many of these sites are being lost to development as a result of government targets for new housing.

Brownfield sites in the Thames Gateway are very important for the brown-banded carder bee (*Bombus humilis*) and the shrill carder bee (*Bombus sylvarum*). The East Thames corridor with its large areas of open flower rich brownfield grasslands is home to the most important remaining metapopulations of these bumblebees.

The streaked bombardier beetle (*Brachinus sclopeta*) was thought to be extinct in Britain but was rediscovered in 2005 on a brownfield site in London (Jones, 2006). The site is currently being developed for housing and as mitigation around 65 beetles have been translocated to a nearby site. Invertebrate translocations typically have a low success rate, particularly with species with complex life histories as is the case with the streaked bombardier. It is therefore highly unlikely that this mitigation will save this species at this site and it may well become permanently extinct in Britain.

The distinguished jumping spider (*Sitticus distinguendus*) was discovered during surveys in 2005 at West Thurrock Marshes (Harvey, et al., 2005). This species is only known from one other site – Swanscombe Marshes where it is threatened by re-development proposals. The site at West Thurrock currently has planning permission for warehousing and car parking which, if developed, would destroy the habitat of this species.

THE SCOTTISH EXPERIENCE

Evidence suggests that this issue is as pressing in Scotland as elsewhere. In September 2010 Buglife launched a new project 'All of a Buzz Scotland' as a response to this challenge. This project follows in the successful footsteps of work completed in the Thames Gateway. The first phase of this project assessed 1,522 sites listed as 'derelict' on the Scottish Vacant and

Derelict Land Register and identified 393 sites that had the potential to satisfy the UKBAP criteria for OMHPDL. The assessment of these sites followed a remote assessment methodology using aerial photography to identify features typical of OMHPDL (Macadam, 2011).

It was noted during this initial assessment that some of the aerial photography was up to 12 years old and the sites identified as potentially fitting the criteria for OMHPDL may no longer qualify as a priority site due to re-development or succession during the intervening period. The next phase of this project is therefore to ground-truth the results from the initial assessment to ensure that we can have confidence in the findings. Advice and information on how to assess a site for the presence of OMHPDL to ensure that Local/Planning Authorities and Government Agencies can identify areas of OMHPDL on 'new' sites in the future will also be prepared. Future phases of the project will promote the management of brownfield sites for biodiversity and provide guidance on tools for mitigation in developments such as green and living roofs, and off-site habitat creation.

The 'All of a Buzz in Scotland' project will produce much-needed evidence and support for planners and developers, enabling them to plan and implement developments in an environmentally sustainable way. It will also promote more natural habitats, native plant species, and a 'less tidy' approach to land management both within developments and in the wider urban landscape.

FALKIRK'S BROWNFIELDS

Buglife has recently undertaken a more detailed investigation of the invertebrate diversity of brownfield sites in the Falkirk area (Bairner and Macadam, 2011). An assessment of the habitat on each of the 76 sites in the Scottish Vacant and Derelict Land Register for Falkirk was undertaken during May 2010. Details of each site were recorded using Buglife's brownfield habitat assessment form and included current activity, the vegetation type, plant species diversity and abundance. Photographs were taken on each site for future reference. Potential invertebrate species diversity was estimated as low, medium or high for each site based on plant abundance and plant species diversity on the site as well as the presence of a mosaic of habitats, including bare ground, scrub and mixed grassland and herbs.

From the sites on the register, 19 were chosen as being important for invertebrates.

Invertebrate survey work was undertaken on 14 of these sites. The remaining sites from the register fitting the OMHPDL criteria were visited for assessment purposes but no invertebrate survey work was possible due to access restrictions. In addition invertebrate surveys were also undertaken at two other sites which are not on the vacant and derelict land register, but have been previously recognised as fitting the criteria for OMHPDL.

Surveys of brownfield sites in Falkirk commenced in May 2010, with the majority of field work carried out between June to October 2010 and March to June 2011. Samples of terrestrial invertebrates were collected using pitfall traps, sweep nets and/or pan traps. When collected each sample was labelled with site name, collection method and date and stored in 70% alcohol. Samples were first sorted into different invertebrate orders and then identified to family, genus or species by close examination under a high power microscope with reference to taxonomic books and keys. Most groups were identified to species, however in the Diptera, Myriapoda, Acari, Collembola and Mollusca a lower taxonomic precision was used in some cases.

Of the invertebrate species collected during survey work 75 have not been recorded from the Falkirk area before. A number of these species are common and widespread in Britain including the green tiger beetle (*Cicindela campestris*) and violet ground beetle (*Carabus violaceus*), the field digger wasp (*Mellinus arvensis*) and marram spider (*Tibellus maritimus*). Results show that 44 of the 72 species of beetle recorded during survey work have not been recorded in Falkirk before. The reason why there are no records for many species, particularly beetles, may be due to the lack of a local biological records centre for the area, although there are relatively few active entomologists in the area.

The diversity of invertebrate species collected clearly shows the importance of brownfields in Falkirk. As an example, the brownfield at Carron Works (Forge Dam) is particularly important due to the high diversity of plants and wildlife, especially the invertebrates that were recorded. Four invertebrate species collected at this site are considered rare or scarce in Scotland:

- The comb-footed spider *Anelosimus vittatus* (Theridiidae) is widespread and common in England and Wales although there are only a few records in Scotland.
- The hobo spider *Tegenaria agrestis* (Agelenidae) is a brownfield specialist and was previously only known from five locations in Scotland (Bo'ness, Grangemouth, two locations in Edinburgh and near Dingwall in the Highlands).
- The Nationally Scarce (Notable B) ground beetle *Amara praetermissa* (Carabidae) was recorded in Bo'ness in the 1980s and during field work three individuals were collected from Carron Works. This represents only the second record of this species in Scotland.
- The rare (RDB3) solitary bee *Andrena ruficrus* (Andreninae) has previously not been recorded from Falkirk.

CONCLUSIONS

Open mosaic habitats with varying stages of natural succession are scarce in the over-managed and farmed countryside. In an urban setting brownfields can be used as 'stepping stones' to allow movement and

mixing of animals and plants across an area (Macadam, 2011). Due to natural succession at these sites, brownfields are transitory habitats and if left un-managed they have a typical lifespan of between 15 and 20 years (Key, 2000; Bodsworth et al. 2005). This is not necessarily a problem as new 'brownfield' sites are always being created. The transitory nature of these sites means that the extent of this habitat will fluctuate as a result of succession, redevelopment and dereliction. The species that inhabit these sites will colonise and retreat in response to the availability of the habitat in each local authority area however it is important that a series of 'stepping stones' are provided as refugia for these species. These 'stepping stone' sites should be managed to retain an open mosaic of habitats for the species that depend upon them.

If properly managed, brownfield sites with high value for biodiversity can not only deliver suitable habitat for many species, but can also transform themselves into wild city spaces full of wildflowers that will attract pollinators and other animals. Such sites are an important part of the habitat network, providing corridors for species to disperse around and through urban areas. Brownfield sites can also provide valuable open spaces for local people and are often seen as being the only truly 'wild' city spaces remaining for the public to enjoy – the 'unofficial countryside'. There is great potential to make many of these sites more accessible, safe and enjoyable through imaginative planning and positive management. In many built-up areas, brownfield sites may be the sole natural greenspace available. If properly managed, they could help significantly to reduce the number of areas deficient in accessible open space, and contribute to the delivery of urban green networks. Improving access to green spaces will bring attendant quality of life and health benefits to residents, as well as economic benefits.

Recommendations made by Bodsworth et al. (2005) for the management of brownfield sites to maximise their value for invertebrate conservation include surveying sites to identify their wildlife interest and the protection of sites from development. Researchers also recommend the management of bare ground, vegetation structure, floristic diversity and shelter to maintain biodiversity at a site once its value has been identified.

The importance of brownfield wildlife in urban areas must be recognised and valued if it is to be protected and managed as a vital component of the townscape. Its long-term survival will depend on the support of the local people who use and value their local environment. Developing opportunities for people to see, enjoy and learn about brownfield invertebrates will help increase awareness and understanding of the value of biodiversity in urban areas.

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Urban Biodiversity: Successes and Challenges: Integrated habitat networks in our dear green space.

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ABSTRACT

The development of the spatial habitat networks known as Integrated Habitat Networks (IHN) was developed with a range of partners using GIS and suite of spatial analyst tools known as BEETLE. The first habitat networks were produced for the Glasgow and Clyde Valley area in 2008. A post was developed to disseminate the resultant woodland, grassland and wetland networks to local authorities and to assist them with the task of utilising these visual networks in development planning, development management and Master planning.

It has been used in a variety of trial projects working with architects, planners, SEPA and SNH and the use of IHN for production of green networks is slowly gaining momentum. A hypothetical use of IHN was illustrated within a presentation at the Glasgow Naturalist conference to visually demonstrate its use in land management and to illustrate the very visual use of the IHN.

INTRODUCTION

In 2009 I started as project officer for the Glasgow and Clyde Valley Green Network Partnership (GCVGNP) and SNH. We are very lucky in Glasgow as the Glasgow and Clyde Valley Structure Plan promotes the vision of a Green Network and the newly emerging Strategic Development Plan carries this vision within its Main Issues Report (MIR). Our area could be considered pioneers of the green network concept as we are fortunate in having a GCVGNP team. In 2008 Forest Research were commissioned to produce habitat networks for the GCV area and to illustrate where these networks "integrated" thus producing Priority Enhancement Areas (PEA's). This was undertaken using GIS and a suite of spatial analyst tools collectively given the name BEETLE (Biological and Environmental Evaluation Tools for Landscape Ecology).

The Planning etc. (Scotland) Act 2006 resulted in the previously non-statutory National Planning Framework (NPF) becoming a statutory document and this is effectively a spatial plan for Scotland. The Act also makes provision for the Framework to designate national developments. Within NPF2 (2009) The Central Scotland Green Network (CSGN) is one of these national developments and the location and design of integrated habitat networks is clearly stated as one of the matters to be addressed in the creation of a CSGN. Additionally the national developments should be included within Strategic Development Plans (SDP) and Local Development Plans (LDP). The IHN has been used to assist within the planning process and small pilot projects have been undertaken in several areas now. To borrow from the Main Issues Report (MIR) for the Edinburgh and South East Scotland SDP (2010) known as SESPlan, the Green Network could be defined:

> "[it] comprises the network of green spaces within and around our towns and cities, linking out into the wider countryside, which underpins the region's quality of life and sense of place and provides the setting which high quality, sustainable economic growth occurs"

SETTING THE SCENE

Spatial tool.

The Integrated Habitat Networks allow us to spatially see where our efforts can be concentrated. We can see very visually see where the habitats cluster into networks and equally we can see where the habitats sit in isolation (Fig.1). Lastly the modelling process gives us an indication of the possible spread of species to surrounding habitat areas by using a process known as least cost distance analysis and this gives an indication of the networks that are possible in the future if there are to be no land use changes. These are the habitat networks illustrated by BEETLE.

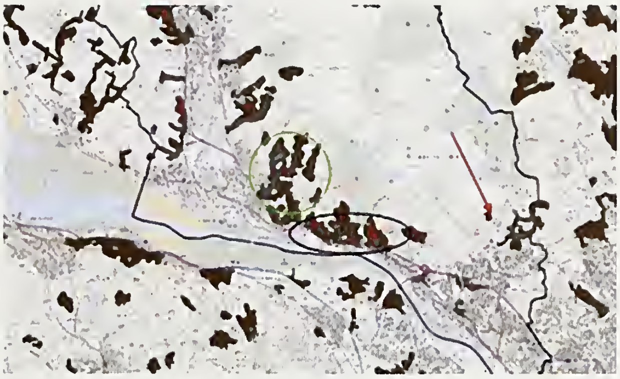


Fig. 1. Example illustrating woodland habitat "clustering" and sitting in isolation

However the question of whether or not to target action to habitat clusters and also the sensitive subject of whether or not to concentrate efforts *only* on these larger areas capable of forming habitat networks will depend on a variety of factors outwith that of forming habitat networks alone. Priorities will vary on an area to area basis but will include factors such as socio-economies, sense of place and therefore local

importance as well as that of providing "stepping stones" for species. The list is not exhaustive.

Uses
To date SEPA and the GCVGN partnership has commissioned a Clyde pilot study "Ecological Networks and River Basin Management Plans (RBMP)" (Entec 2010) in order to to align the RBMP objectives with an IHN for this area. Opportunities have been identified addressing diffuse pollution and reduction of morphological pressures on watercourses whilst also enhancing the IHN . It has also been used to aid the master planning process in Glasgow and South Johnstone and at development plan level was used in the Strategic Environmental Assessment for the South Lanarkshire Minerals Plan.

What does it actually do?
The IHN addresses habitat fragmentation by very visually illustrating the habitats that are in existence and the concentration is on wetland, woodlands and grasslands. Using a focal species approach to assess the functional connectivity of habitat for species distribution, a limited number of species were used to map the IHN's. This generalises the species requirements for a particular habitat and is widely used in habitat network modelling. It also removes the need to carry out a large number of individual species analyses (Smith 2008). Those used have included mountain hare *Mustela putorius*, great crested newt *Triturus cristatus*, red admiral *Vanessa atlanta* , dogs mercury *Mercurialis perennis* and water avens *Geum rivale* (Fig. 2). They encapsulate species requirements for particular habitats. Similar habitats in turn have been collated to form generalist habitats, woodland, wetland and grassland (Fig. 3) it is however possible to separate the network components to show specialised networks using GIS. Networks such as acid grassland and ancient woodland can be clearly illustrated for example and this ability to "drill down" may prioritise our land management decisions in the future.

The process of habitat network modelling has been taken a step further near Inverness as part of the planning process for Tornagrain to try to ensure that red squirrel strongholds are retained and expanded using the least cost distance analysis pioneered by Scottish Natural Heritage and Forest Research. Maps have been produced to illustrate the existing red squirrel areas and also the areas that could host red squirrels. All possible very quickly by computer modelling.

IHN MODELLING IN GLASGOW
The city of Glasgow is always depicted as the "dear green place". The IHN generalist habitat layers allow us to see where our networks lie and see where there is habitat fragmentation. Phase 1 data, master map and a variety of other data sets have been used to calculate the networks. Note that the habitat networks are not wildlife corridors. They are a component of the green network but the habitats within the IHN must fulfil certain criteria to be part of this so for example amenity grassland is generally not part of the habitat network. As mentioned previously it is even possible to further refine our visual display to show where our areas of ancient woodland are within the woodland generalist layer and additionally to use the modelling process to show how the network could expand (Fig. 4).

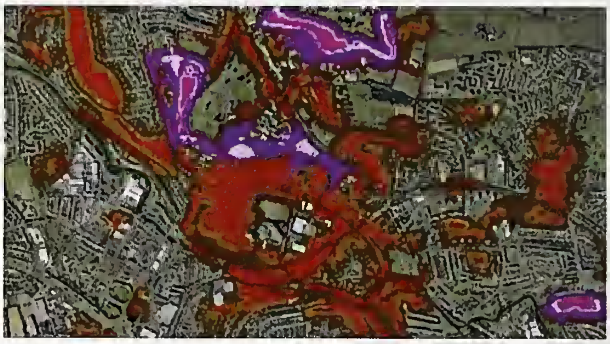
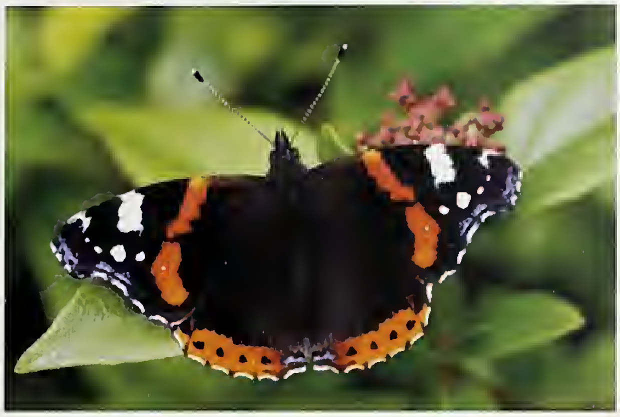


Fig. 4. Data licensed to Scottish Natural Heritage under the PGA, through Next Perspectives. Glasgow generalist woodland network (red), ancient woodland network (pink) and lilac and purple showing the possibility for expansion of the ancient woodland network.

To explain the IHN's possibilities it will be necessary to set the scene. Imagine that Glasgow has undergone a population explosion that necessitates the local authority to consider development of Dawsholm Park. I use this example because it is an instantly recognisable area on a map and it is an area valued for reasons other than that of being a valuable component of the IHN's! Fig. 4 shows that within the north west of Glasgow there is a substantial area of ancient woodland and also potential for ancient woodland expansion. However to look at the ancient woodland network for the whole of Glasgow (Fig 5) it is possible to see that these areas of ancient woodland are scarce throughout the city. Equally on a larger scale we can see at a glance where the habitat networks in Glasgow integrate and although the ecologists amongst us will be well aware of these "hotspots" it allows us to visually show the high habitat value of areas such as Possil Marsh SSSI which is an important *component* of the IHN. It does not sit in isolation (Fig. 5). Where the habitats networks integrate can be clearly seen as can areas that could be improved by appropriate land management can also be identified helping us to prioritise our habitat management.

Mountain hare *Lepus timidus*. © Lorne Gill



Red Admiral *Vanessa atalanta* © Lorne Gill.

Great crested newts *Triturus cristatus* © Sue Scott/SNH.

Water avens *Geum rivale* © Lorne Gill.

Dogs mercury *Mercurialis perennis*. © Lorne Gill/SNH

Fig. 2. Some of the focal species used for IHN analyses.

Woodland © Lorne Gill.

Wetland © Lorne Gill/SNH

Grassland habitat. Lorne Gill/SNH.

Fig. 3. Generalist habitats.

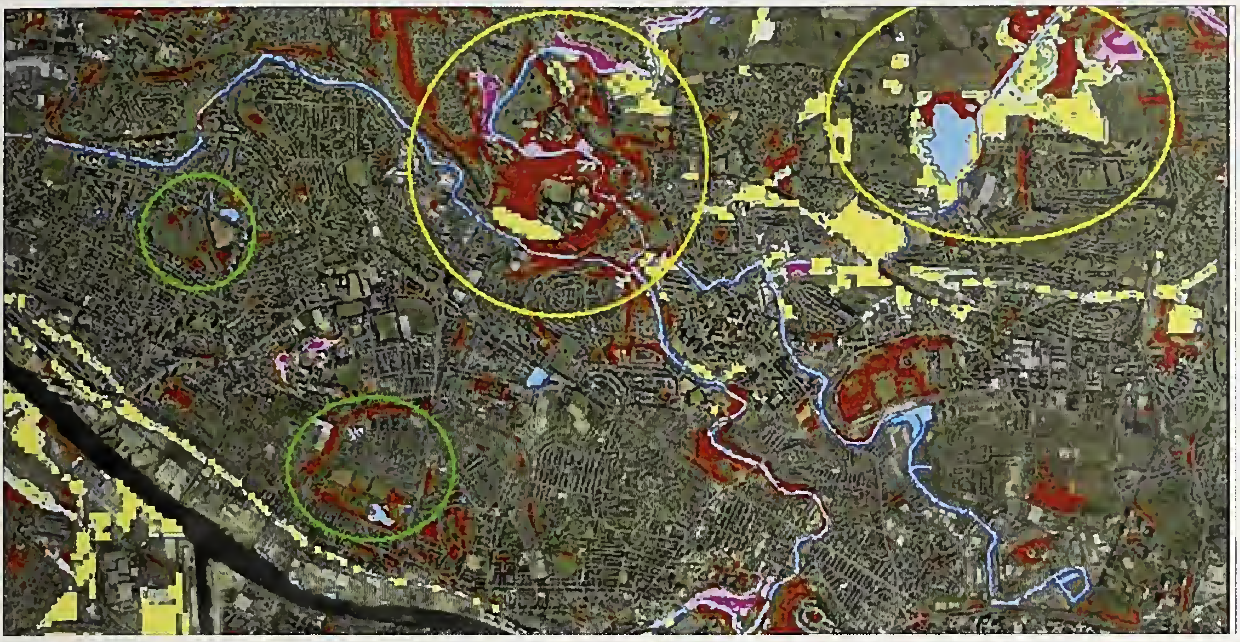


Fig. 5. Data licensed to Scottish Natural Heritage under the PGA, through Next Perspectives. Generalist woodland networks (red), ancient woodland (pink), grassland including marshlands (yellow and green) and wetland (blue).

WEB BROWSER TOOL

Scottish Natural Heritage is presently working on a web browser tool to allow all of us with a land management interest to access the IHN layers to assist with our land management decisions. It will be possible to graphically see the effect of development, land use changes and also to assist land agent with their Scottish Rural Development Priority applications as there will be a web browser tool to allow us to add and for that matter remove land to see the effect on the habitat networks. The ecological network modelling will be possible throughout Scotland and access will be possible via the SNH website. www.snh.org.uk.

CONCLUSION

The IHN is a spatial took which can assist us with our efforts to plan our green networks in only one area but also across our various local authorities. There will always be an element of ground truthing required but then the same can be said of any desk top analysis. Importantly we have the opportunity to strategically address habitat fragmentation and have a tool to assist us with the best possible "locations" for expansion of these networks.

FOOTNOTE

Since the conference in October IHN's have been created for the whole of the Central Scotland Green Network area. Data and further information can be obtained from the Central Scotland Green Network Support Unit.
http://www.centralscotlandgreennetwork.org.

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Urban Biodiversity: Successes and Challenges: The Biodiversity in Glasgow (BIG) project: the value of volunteer participation in promoting and conserving urban biodiversity.

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INTRODUCTION

Glasgow is an ideal city in which to look at urban biodiversity. Over 20% of the area of Glasgow is green space including 74 parks, over 30 allotment spaces and other sites of potential importance to urban biodiversity such as rivers, woodlands, cemeteries and eommunal gardens. In terms of nationally recognised status of nature conservation, Glasgow holds 5 Sites of Special Scientific Interest (SSSIs) and 7 Local Nature Reserves (LNRs). It also has 46 and 49 Sites of Importance for Nature Conservation (SINCs) at the City and Local level respectively[1]. Glasgow City Council (GCC) in a strategic review of its green spaces identified a numbers of key actions including: (a) identifying amenity grass and road verges that could be subject to less intensive maintenance and; (b) the inclusion of biodiversity as an integral part of any development projects (GCC, 2005). GCC also has a programme of habitat enhancement including the naturalisation of artificial ponds and creation of further ponds and wetlands, wildflower meadows and native woodland. In addition the Glasgow Biodiversity Partnership has produced a Local Habitat Statement on "Built Up Areas and Gardens", as part of the Local Biodiversity Action Plan (LBAP) which highlighted the need to raise awareness of urban biodiversity through promoting access, encouraging public participation and the use of appropriate management practices[2].

[1]http://www.glasgow.gov.uk/en/AboutGlasgow/Factsheets/Glasgow/Environment.htm.
[2]http://www.glasgow.gov.uk/NR/rdonlyres/5CF1528F-ABBC-4F8F-A3CC-AD6CFD8E98CB/0/LBDAPurban.pdf

The importance of urban biodiversity has also been highlighted in the Scottish biodiversity strategy, a 25 year plan for the conservation and enhancement of biodiversity in Scotland. This document sets out five main objectives: halting the loss of biodiversity; increasing awareness of biodiversity and engaging people in conservation; restoring and enhancing biodiversity in urban, rural and marine environments; ensuring that biodiversity is taken into account in all decision making and; ensuring that existing knowledge on biodiversity is available to all policy makers and practitioners (Scottish Government, 2004). The Seottish Biodiversity Forum, in its implementation plans for 2005-2008, has also highlighted that urban green spaces are often poorly managed and sometimes dominated by non-native invasive species that are generally of low value for urban wildlife (Scottish Government, 2005). Consequently, urban environments such as green spaces and corridors offer huge potential for improvement through schemes to conserve and enhance biodiversity.

The Biodiversity in Glasgow (BIG) project was set up as a collaboration between the British Trust for Ornithology Scotland, Butterfly Conservation Scotland and Glasgow City Council and ran from January 2007 to April 2009. The main aim of the project was to carry out the largest ever volunteer survey of the birds, butterflies and their associated habitats within the green spaces of the city. This information was then used to determine which habitats are the most important in terms of enhancing bird and butterfly diversity within green spaces.

METHODS

Site allocation and training

More than 100 green spaces were surveyed during the BIG project and full details are provided in Humphreys *et al.* (2011). The term green space, as used here covers a wide range of sites (eg. parks, cemeteries, allotments, urban woodlands, open spaces[3]) and in over 90% of cases were owned by GCC. Site allocation was based on proximity to either where volunteers lived or worked and wherever possible, were chosen by volunteers themselves. The size of green spaces used in the BIG project ranged from just under 2 ha to 168 ha (although the largest sites were subdivided for the purpose of surveying).

Although some of the BIG volunteers were highly experienced, many people had never carried out a survey before. Free training in species identification and survey techniques was therefore offered to all participants. A total of 108 and 88 people were trained for the bird and butterfly surveys respectively. Volunteers also received regular newsletters throughout the project which featured interim results,

[3] The category of open space describes the various combination of a wide range of possible habitats which are not intensively managed including: wetland, raised bog, burns, woodlands, heathlands, pasture and open water.

personal accounts by participants and articles on the best green spaces in Glasgow to visit.

Bird Surveys

Volunteers were recommended to make a pre-survey visit in early April in order to estimate the percentage cover of the different habitats within their site. Three further visits were then made: mid April to mid May, mid May to mid June and mid June to mid July. Ideally survey visits were carried out between dawn and 09:00 but if that was not possible, observers were required to choose a time of day that was convenient and carry out future surveys at this fixed time. Volunteers were requested to walk a survey route in such a way that they covered the whole site to within 50m ensuring that they did not double count any birds eg. either by zigzagging or using parallel lines. Any bird species seen were then counted and allocated to the habitat type in which they were first seen. Species lists for all sites were checked over by GCC staff to identify records that were unlikely. In such instances, if these sightings could not be validated, they were subsequently removed from the site lists (see Humphreys *et. al* 2011).

Butterfly and day-flying moth Surveys

Volunteers were recommended to undertake a pre-survey visit in early May in order to set up their transect routes and estimate the percentage cover of the different habitats within their sites. Transects were designed to take less than 60 minutes, not exceed 2 km in length, and cover a fair representation of the habitats present at the site. A minimum of four monthly visits to carry out the transects were recommended: mid May-mid June, mid-June to mid July, mid-July to mid-August and mid-August to mid-September. Volunteers were requested to walk at a slow, steady pace counting all butterflies and any day-flying moths seen within 2.5m either side of the transect line and 5m ahead. Transects were to be carried out between 10:45 and 15:45 hours BST and ideally in good weather conditions (eg. minimum temp of 11°C and wind speeds less than 5 on the Beaufort scale). All records of butterflies were checked by BC Scotland volunteers who were able to flag up records which were questionable (based on location and time of year). In such instances unless validation was provided the record was deleted (see Humphreys *et. al* 2011).

RESULTS

Birds

A total of 91 species of bird was recorded in the city of Glasgow during the BIG project (with up to 61 species being recorded at one site alone). As expected, many birds were relatively abundant species, but what was surprising was the number with high conservation value. In total, there were 15 UKBAP and 4 LBAP birds species recorded along with 47 species of Birds of Conservation Concern (see Eaton *et al.*, 2009, for definition and Table 1). These key lists included species that have become synonymous with the urban environment such as House Sparrow, Swift and Starling, as well as species that are more commonly associated with rural habitats including Tree Sparrow, Skylark and Yellowhammer.

Analyses were then carried out to look at the habitat associations of birds (see Humphreys *et al.*, 2011 for further details). Species richness was most influenced by the overall size: the larger the green space, the higher the species richness was likely to be. The presence of wild areas (unmown rank grass or wild/weedy areas) had the greatest single effect, with an average of 5.2 more species in green spaces where wild areas were present. The presence of a water body (natural or ornamental) was also found to be important. Green spaces with a water body had an average of 4.9 more species than those without. Furthermore, sites with a wetland/marsh area present had on average 2.8 more species than those sites without.

Butterflies and day-flying moths

Seventeen species of butterflies and 9 species of day-flying moths were recorded in the City of Glasgow by volunteers despite the relatively wet and cold conditions, particularly in 2008 when records were notably lower throughout the whole of the UK. Two species of butterfly had UKBAP listings: Small Heath and Grayling (Fox *et al.*, 2006). Exciting records included Comma, which was the first record for the city. The Comma is a generalist species that has a southerly distribution in Britain, although over the past few decades it has shown northern range expansions, almost certainly due to climate change (Warren *et al.*, 2001) and is therefore likely to become much more widespread in the future. Also of interest were the good numbers of Ringlets which indicate the rapid rate of colonisation of Glasgow by this particular species, which was first reported within the city boundary in 2005. There were conspicuously low numbers of the Common Blue, however, which is consistent with the documented widespread decline across the UK (Botham *et al.*, 2008).

Simple analyses were then carried out to compare the key habitat features of sites in which butterflies were recorded with those of sites having nil records (there were too few records for day-flying moths for any analyses to be meaningful). The mean percentage covers of wildflower/weedy areas for sites with and without butterflies were not significantly different. However, the mean percentage cover of unmown or rank grass was significantly higher for those sites with butterflies compared with those without. This suggests that the area of unmown grass could be an important determinant of whether butterflies will be present.

RECOMMENDATIONS FOR GREEN SPACE MANAGEMENT

Birds

The overall size of the green space was the most influential factor in determining species richness for birds. Larger sites by their very nature however are more likely to contain a greater number of habitats. Consequently it is difficult to tease apart the relative importance of size of green space in relation to greater

diversity of habitats (Chamberlain *et al.*, 2007). Although the size of existing sites cannot be easily augmented, there may be potential to increase area by landscaping adjacent land Alternatively there could be opportunities to join up existing green space through the creation or enhancement of corridors, defined here as linear features with continuous wildlife habitat. Larger green spaces could be incorporated into the design of new towns.

Wild areas (e.g. patches of unmown rank grass and wild/weedy habitats) were also important.These particular habitats holding important numbers of invertebrates or being an important resource for seeds, particularly outside the breeding season. The presence of water bodies creates opportunities for an additional water bird community which could otherwise not be supported e.g. ducks and geese some of which have conservation listing (see Table 1). Wetland and marsh areas were also important for overall species richness and therefore, should accompany the creation of water bodies. Moreover for existing water bodies, there may be scope to incorporate wetland habitat if they do not already exist (e.g. naturalisation of water bodies).

Butterflies

Unmown/ rank grass was shown to be an important factor in determining the presence of butterflies. Some sites, however, had unexpectedly poor numbers of butterflies despite having a high percentage. In such cases, the grassland was likely to be of amenity or agricultural origin and thus of little value to butterflies and moths as food resource (although it may provide over wintering habitat). In such instances the creation of new wildflower-rich or semi-natural grassland should be considered instead.

Consideration should also be given to the frequency of cutting regimes as nectar sources and caterpillars are destroyed by regular mowing. Even annual mowing of grasslands will cause losses to most butterflies and moths, except perhaps those that pupate in the soil. Thus if the site has to be mown, it is always better to have a variety of cutting regimes so a proportion of the population has a chance of survival.

CONCLUSIONS AND LESSONS FOR THE FUTURE

The BIG project was extremely successful in encouraging new volunteers to go out and survey birds and butterflies. Volunteers had often previously felt that they lacked the skills or the confidence to get involved, so offering targeted training really was key to the success of the project. The first-time surveyors also reported taking great satisfaction in developing their identification skills as the project progressed, which really reinforces the message that the only way to truly learn is to get out there and practise!

There was also an issue of people's perception of green spaces particularly when volunteers were allocated a site that was previously unknown to them. A number of volunteers actually voiced their initial misgivings over what were seemingly uninviting green spaces in the spring but by mid summer many of these sites had transformed. Participants also expressed their sheer joy at discovering birds and butterflies found at their site that would have been potentially overlooked by a casual visit.

By informing the management of urban greenspace and promoting the awareness of urban biodiversity, the BIG project made a significant contribution to the LBAP process. GCC has gone onto to be involved with the Glasgow Living Water Project, a partnership with Froglife which has resulted in the creation of new ponds across the city and North Lanarkshire. Although the management of these water bodies is intended to benefit primarily amphibians, it is likely to enhance overall biodiversity. In addition, in 2011 the council started a new partnership project with Buglife called Glasgow's Buzzing which will create and enhance grasslands and meadows for the benefit of bees, butterflies and other key invertebrates. Although the BIG project was initially specific to Glasgow, any generic management advice will have applications for urban green spaces across Scotland and will therefore support the objectives of the Scottish Biodiversity Strategy. Therefore, if lessons from the BIG project are applied to other cities and towns, then we have demonstrated how anyone can help contribute to promoting and conserving biodiversity in Scotland.

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Species	UKBAP	LBAP	BOCC
Pink-footed Goose			Amber List
Greylag Goose			Amber List
Gadwall			Amber List
Mallard			Amber List
Northern Pintail			Amber List
Common Pochard			Amber List
Tufted Duck			Amber List
Grey Partridge			Red List
Little Grebe			Amber List
Common Kestrel			Amber List
Eurasian Oystercatcher			Amber List
Ringed Plover			Amber List
Northern Lapwing	UKBAP		Red List
Eurasian Curlew	UKBAP		Amber List
Common Sandpiper			Amber List
Black-headed Gull			Amber List
Common Gull			Amber List
Lesser Black-backed Gull			Amber List
Herring Gull	UKBAP		Red List
Stock Dove			Amber List
Common Cuckoo	UKBAP		Red List
Common Swift		LBAP	Amber List
Kingfisher			Amber List
Skylark	UKBAP	LBAP	Red list
Meadow Pipit			Amber List
Grey Wagtail			Amber List
Sand Martin			Amber List
Barn Swallow			Amber List
House Martin			Amber List
Dunnock			Amber List
Whinchat			Amber List
Wheatear			Amber List
Song Thrush	UKBAP		Red list
Mistle Thrush			Amber List
Grasshopper Warbler			Red List
Whitethroat			Amber List
Wood Warbler			Red List
Willow Warbler			Amber List
Spotted Flycatcher	UKBAP		Red List
Starling	UKBAP		Red list
House Sparrow	UKBAP		Red List
Tree Sparrow	UKBAP	LBAP	Red List
Common Linnet	UKBAP		Red List
Lesser Redpoll	UKBAP		Red List
Bullfinch	UKBAP		Amber List
Yellowhammer	UKBAP		Red List
Reed Bunting	UKBAP	LBAP	Amber List

Table 1. Species of bird recorded in Glasgow as part of the BIG project which had a conservation listing. BOCC, Birds of Conservation Concern; LBAP, Local Biodiversity Action Plan; UKBAP, UK Biodiversity Action Plan.

Species	UKBAP	LBAP
Small Heath	UKBAP	
Grayling	UKBAP	

Table 2. Species of butterfly and moths recorded in Glasgow as part of the BIG project which had a conservation listing.

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Urban Biodiversity: Successes and Challenges: Bat activity in urban green space

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ABSTRACT

Green spaces within urban areas can be important for ameliorating the impacts of urbanisation on biodiversity, and can hold relatively rich wildlife communities. In contrast to some other taxa, relatively little is known about the ecology of bats in urban environments, and in this study we aimed to identify site-specific and wider landscape features that influence bat foraging activity within areas of urban green space. Bat activity primarily comprised *Pipistrellus pygmaeus* and was detected at 86% of parks surveyed. The presence of water bodies and woodland in urban parks increased bat foraging activity by a factor of 3.2 and 1.7 respectively. Data presented in this study indicate that, for this species, habitat within a site may be more important than the level of urbanisation or woodland cover in the surrounding landscape.

INTRODUCTION

Urbanisation and green space

Urbanisation by expanding human populations reduces native biological diversity by decreasing the amount and quality of habitat available for wildlife, and by the fragmentation of remaining habitats (e.g. Marzluff *et al.,* 1998). It has been estimated that currently 50% of the world's population live in areas classed as urban, a figure set to increase along with the human population (United Nations, 2008). Urban development will therefore continue to grow, resulting in further losses of natural and semi-natural habitats, and increasing pressure on remaining habitat fragments which may suffer increasing isolation and deterioration in quality

(Marzluff and Ewing, 2001; Chamberlain *et al.*, 2007). Green spaces within urban areas (e.g. parks, domestic gardens) typically consist of small, highly disturbed or modified patches of vegetation distributed within a matrix of urban development such as buildings and associated infrastructure. Whilst several studies have shown that species diversity for several taxa decreases along the rural-urban gradient (e.g. Sadler *et al.*, 2006; Duchamp and Swihart, 2008), green spaces can nevertheless ameliorate the impacts of urbanisation on biodiversity, and may hold relatively rich wildlife communities (e.g. Chamberlain *et al.*, 2007; Davies *et al.*, 2009). Factors commonly found to influence the abundance and diversity of several taxa (birds, mammals, invertebrates) include the size, habitat quality and structure of green spaces, although the quality and proximity of suitable habitat in the wider landscape can also be important (e.g. Sadler *et al.*, 2006; Baker and Harris, 2007; Chamberlain *et al.*, 2007). Clergeau *et al.*, (2001) and Angold *et al.*, (2006) argue that appropriate management within areas of urban green space areas can benefit many avian and invertebrate species regardless of the surrounding landscape, and such actions may be far easier to implement. However, the relative importance of local habitat versus the wider landscape is likely to vary markedly between species depending on their ecological requirements and mobility.

Status and conservation of bats in Europe

There is evidence that many bat species in Europe have undergone large population declines during the 20th century, driven by the loss of foraging and roosting habitat. A UK-wide bat survey in the 1990s found that habitats favoured by foraging bats were undergoing rapid rates of loss within the UK, and suggested that this may be limiting bats in some areas (Barr *et al.*, 1993; Walsh *et al.*, 1996). Although it remains the most abundant and widespread bat genus in the UK, estimates from the Annual Bat Colony Survey in the UK suggest a decline of over 60% between 1978 and 1993 for *Pipistrellus* spp. (Hutson, 1993). The species *Pipistrellus pipistrellus* was only recently recognised as two separate species, *P. pipistrellus* and *P. pygmaeus* (International Commission on Zoological Nomenclature, 2003), so it is not known whether this decline has affected both species equally.

In order to sustain bat populations, urban areas need to provide both roosting and foraging sites, and routes which allow bats to commute between the two. Some bat species now commonly use buildings as maternity roosts, and exploit foraging opportunities provided by man made structures such as streetlamps and sewage works that are associated with high insect densities (Rydell, 1992; Altringham, 2003; Park and Cristinacce, 2006). Several studies have suggested that urban environments may have a positive role to play in resource availability for bats (e.g. Avila-Flores and Fenton, 2005; McDonald-Madden *et al.*, 2005; Haupt *et al.*, 2006), particularly in landscapes dominated by intensive agricultural land use, which studies have repeatedly found are avoided by bats (Walsh and Harris, 1996; Gehrt and Chelsvig, 2003). There appear to be marked species-specific responses to urbanisation, however, with other species strongly avoiding built up areas (e.g. Kurta and Teramino, 1992; Waters *et al.*, 1999; Lesińki *et al.*, 2000).

Understanding how different species use urban environments and how habitat management and urban planning can promote population persistence is critical to their conservation. The aim of this study was therefore to identify site-specific and wider landscape features (e.g. woodland connectivity, urbanisation) that influence bat activity within areas of urban green space.

MATERIALS AND METHODS

Study sites

Glasgow is the largest city in Scotland (UK), with the Greater Glasgow conurbation covering an area of 369km^2 with a population of approximately 1.2 million people. Over 20% of the area of Greater Glasgow is green space; including 74 parks and other potentially important features such as river corridors, woodlands, cemeteries and communal gardens (Humphries *et al.*, 2009). Other than two very large sites (>140 ha), green space areas owned by Glasgow City Council (GCC) range from 1.5 – 68.4 ha (mean 18.2). A total of 29 sites owned and managed by GCC were surveyed for bat activity between 31 May and 11 July 2007 (Table 1). Sites were chosen randomly whilst ensuring they were a minimum of 1km apart and spanned a range of sizes (mean 24.3 ± 14.9; range 6.2 – 53.2 ha).

Monitoring bat activity

Point counts were used to quantify bat activity. At each park 10 minute recordings were made at between two and six locations depending on the size of the park (across parks, an average of four point counts were recorded). Each point location was chosen using randomly-generated xy coordinates but omitting areas of open water within the park and ensuring a minimum distance of 30m between points. On each survey night, one of four geographical areas of Glasgow (NE, NW, SE, SW) was chosen randomly, and between one and four parks were surveyed, again in random order, with each park being surveyed once. Within a night, all point counts were conducted within 2 h 15 minutes of each other, the first starting 45 min after sunset. At the start of each count air temperature was measured to the nearest 0.1°C and wind speed was estimated using the Beaufort scale. Counts were only conducted in dry weather where the temperature at dusk exceeded 10°C and the strength of the wind did not exceed Beaufort 3 (since strong winds influence both insect distribution and detectability of bat calls).

Sound recording and analysis

A frequency division bat detector (Batbox Duet, Stag Electronics; frequency response 17-120kHz) was connected to a MiniDisc (Sony MZ-R909; frequency

response ± 3dB 20Hz – 20kHz) and a continuous recording made for each point count onto a recordable MiniDisc. Frequency division is a broad-band system that records all frequencies continuously, and is sufficient for distinguishing between the genera *Myotis* and *Pipistrellus*, and between the *Pipistrellus* species (e.g. Vaughan *et al.*, 1997a; see sound analysis). We analysed recordings using BatSound v3.31 (Pettersson Elektronik AB, Uppsala, Sweden), with a sampling frequency of 44.1kHz with 16 bits per sample, and a 512 pt. FFT with Hanning window). One bat pass was defined as a continuous sequence of at least two echolocation calls from a passing bat (Fenton, 1970; Walsh *et al.*, 1996).

Three genera of bat occur in the area where this study was conducted; *Pipistrellus*, *Myotis* and *Plecotus* (Richardson, 2000), although *Plecotus* is rarely recorded due to its quiet echolocation calls. Unfortunately, problems with the recording equipment meant that for all but seven parks (representing 25% of the point counts) recordings were made in mono (heterodyne) rather than stereo (heterodyne and frequency division. Analyses were therefore conducted on the number of bat passes per point count. Terminal feeding buzzes emitted when attempting prey capture were also counted and provide a measure of foraging effort.

Habitat availability within, and surrounding, urban parks

Habitat structure within the parks was fairly simple consisting largely of a mixture of improved grassland, mixed woodland and shrubs. All but one park had some mixed woodland on site, although there was considerable variation in the amount among parks (0.3 - 45ha). Of the parks surveyed, 21 had still (> 3m width) or running water (> 1m width) present. Habitat within 30m of each recording point was categorised according to the presence of woodland and still or running water. Of 111 point counts made, 31 were adjacent to water (i.e. within 30m), 50 were adjacent to woodland, 12 were adjacent to both water and woodland and 42 were made within grassland with no water or woodland nearby.

The landscape analysis was performed using data from OS MasterMap Topography Layer (Digimap Ordnance Survey® Collection). We used ArcGIS 9.2 to create buffers of 1 km radius around the centre of each park and reclassify the feature classes from the topography layers into five categories (hereafter referred to as habitat classes). These were: 1) urban areas (buildings, structures, roads and parking areas); 2) urban gardens (urban land not covered by buildings or structures); 3) grassland and scrub; 4) woodland (coniferous, deciduous and mixed woodland, and areas covered by scattered trees); 5) water (inland and tidal water). A 6th category (called "other") included features that didn't fall into any of the 5 previously mentioned habitat classes, but its proportion was less than 4% in all cases. Because the 1 km radius was taken from the centre of the park rather than the location of individual points, the proportion of the 3.14 km^2 circle that lies outside the park varies between parks, although this variation is relatively small (non-park area: 83-98%). We then used the software package Fragstats 3.3 to calculate a selection of different landscape metrics for each habitat class within the 1 km buffer including the proportion of land covered, the number of patches, mean patch area, largest patch, total edge density, area-perimeter ratio and Euclidean nearest neighbour distance (ENN distance is the shortest straight-line distance between the focal patch and its nearest neighbour of the same class; McGarigal *et al.*, 2002).

The proportions of different habitat categories within a 1km radius of a park are not independent since all must sum to 1. Our purpose for including information about the habitat surrounding each park as potential explanatory variables in the model was to assess how bat activity may be influenced by levels of urbanisation and proximity of habitats considered important for many bat species, for example woodland. We focused, therefore on the proportion of urban and woodland habitat, and the mean ENN distance among water bodies within a 1km radius of the centre of each park. The size of the park was significantly positively correlated with the proportion of woodland within the 1 km buffer (t_{27} = 2.70, p = 0.012, r^2 = 0.21), and % woodland cover was weakly negatively correlated with % urban cover (t_{27} = -2.05, p = 0.05, r^2 = 0.13) but neither of these was sufficiently strong to cause problems with multicollinearity. There was no correlation between % urban cover and the size of the park (t_{27} = 0.23, p = 0.76, r^2 = 0.0019). Percentage woodland and urban cover were arcsine square root transformed prior to analysis.

There are many different metrics that can be calculated to assess the composition and configuration of habitat patches within a landscape, and therefore potentially a great many potential explanatory variables. We minimised the number of potential variables describing the configuration of woodland patches within the surrounding landscape as the proportion of woodland within a 1km radius of each park correlated strongly with several measures commonly used to assess isolation of that habitat (McGarigal *et al.*, 2002). For example, proportion of woodland was strongly correlated with both edge density (t_{27} = 4.51, p = 0.0001, r^2 = 0.43), and weighted-mean ENN distance (t_{27} = -3.78, p = 0.0008, r^2 0.35).

Data analysis

All statistical analyses were conducted using the R computing environment (version 2.8.1, R Development Core team, 2008). To assess the influence of habitat features and the surrounding matrix on bat activity in urban green space, we fitted a Generalised Linear Mixed Effects model with quasi-poisson errors using the number of bat passes at each location (n=111), as the dependent variable. The following were included in the starting model as potential explanatory variables:

the presence or absence of a water body or woodland adjacent to each point count (within 30m) were included as fixed factors; the order in which the points were surveyed (i.e. to account for variation of activity with time of night), the proportion of woodland and urban cover, and the mean ENN distance between water bodies within a 1km radius of the centre of the park, the size of park, wind speed, temperature (linear and quadratic terms) were covariates. A two way interaction between park size and each of the landscape metrics was also included. Park was a random factor used as a grouping variable. The model was carried out in a stepwise fashion, with the least significant of the explanatory variables being removed at each step in an effort to determine which of these variables had the most significant effect.

RESULTS

Bat activity

A total of 852 bat passes was detected during 18.5 hours of recording during the study. On average, 14.7% of bat passes had feeding buzzes and evidence of feeding activity was detected at 62% (18/29) parks. There was a significant positive correlation between the number of bat passes and feeding buzzes per park (Spearman rank $r_{s29} = 0.79$, $p < 0.0001$), suggesting that the use of bat passes is a reasonable measure of foraging activity.

For the seven parks (28 point count locations) at which bat passes could be assigned to species level (see Methods), 128 of 160 (80%) of identified *Pipistrellus* passes were attributable to *P. pygmaeus*. Total bat activity within urban parks was significantly higher adjacent to water bodies or areas of woodland; based on differences in the adjusted median values, the presence of water bodies and woodland increased bat activity by a factor of 3.2 and 1.7 respectively (Table 2, Figs. 1 and 2). The final model explained 56% of the variation in activity among point counts. There were no significant interactions between the size of park and the surrounding landscape variables (proportion of urban, proportion of woodland, mean ENN distance between water bodies within a 1km^2 radius around each park), and none of the landscape variables had a significant influence on bat activity on their own.

In this study wind speed correlated positively with bat activity (Table 2) although this relationship is entirely reliant on the data point with the highest bat activity and, if removed, wind speed becomes non-significant. The remaining variables in the model, however, are all retained.

DISCUSSION

The presence of both water bodies and woodland in urban parks resulted in significantly increased bat activity, with the effect of water being the most marked. This is likely to be because the majority of bat passes recorded during these surveys were of *P. pygmaeus* which, of the two most common pipistrelle species in the UK, is particularly associated with riparian habitats (Vaughan *et al.,* 1997b; Nicholls and Racey, 2006; Sattler *et al.,* 2007). The importance of water bodies within urban green space for birds has recently been highlighted by the Biodiversity In Glasgow project, co-ordinated by the British Trust for Ornithology (Humphries *et al.,* 2009). Between five and 61 bird species were recorded within urban green spaces in Glasgow, with sites containing water bodies having an average of five more species than those lacking water.

Previous studies have shown the importance of deciduous or mixed woodland for foraging bats (e.g. Walsh and Harris, 1996; Johnson *et al.,* 2008), and areas with higher proportions of well connected woodland might have been expected to have had higher levels of bat activity as found by Gehrt and Chelsvig, 2003. In this study, however, although woodland adjacent to recording sites had a positive effect on levels of bat activity (largely *P. pygmaeus*), the amount and connectivity of woodland at a larger scale did not.

Previous work has indicated that species respond differently to urbanisation which, given the marked differences in roosting and foraging ecology among bat species, is not surprising. Gehrt and Chelsvig (2004) found positive associations between urban indices and activity of *Eptesicus fuscus, Lasiurus borealis and L. noctivagans.* Other species, however, appear to largely avoid urban areas (e.g. *Nyctalus leisleri* – Waters *et al.,* 1999; *Myotis sodalis* – Sparks *et al.,* 2005) or are otherwise sensitive to features associated with urbanisation such as street lighting (e.g. *Rhinolophus hipposideros* – Stone *et al.,* 2009). Duchamp and Swihart (2008) identified two groups of bat species whose populations showed opposite trends along urban and forest gradients. Species that responded negatively to urban development were those requiring tree cavities for roosting and a wing morphology adapted to flight in cluttered environments such as woodland (ie. low wing loading), whereas the opposite was true for species that responded positively to urbanisation. These predictions fit well with our findings for *P. pygmaeus,* the most frequent species recorded during this study, which is commonly associated with building roosts and adapted to flight in relatively open environments. It might be expected that the two *Myotis* spp. commonly found in Scotland would react differently to urbanisation: *M. daubentoni* is also associated with riparian habitats but typically roosts in tree cavities or within the stonework of bridges, and *M. nattereri*, also a tree rooster, forages largely in woodland habitats (Altringham 2003).

Data presented in this study suggests that, for *P. pygmaeus*, the habitat within a site may be more important than the surrounding landscape as Gilbert (1989) suggested may be the case for highly mobile species within urban environments. That the size of park was not an influential factor on *P. pygmaeus* activity suggests that even small areas of urban green space can provide valuable foraging opportunities for bats able to adapt to urbanised landscapes, provided

there is suitable habitat (ie. water bodies and woodland) within the site. For other species, however, a wider landscape-approach, such as increasing woodland cover both within urban parks and in the surrounding matrix to link foraging areas, is likely to be necessary.

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Site name	Latitude	Longitude	Size (ha)	Date surveyed	Surrounding habitat		
					% urban	% woodland	Mean ENN distance water[a]
Auchinlea Park	55° 52' 16.96"	-4° 8' 1.81"	29	11/07/2007	24.6	5.5	395.0
Cardonald Park	55° 51' 27.26"	-4° 20' 55.78"	7	18/06/2007	32.6	3.3	57.4
Cardowan Moss Woodland	55° 52' 48.28"	-4° 9' 1.09"	45	10/07/2007	16.2	16.8	57.1
Cleddans Burn	55° 54' 51.80"	-4° 23' 9.14"	15	04/06/2007	14.6	9.4	40.1
Cowlairs Park	55° 52' 42.12"	-4° 14' 46.12"	17	06/06/2007	30.7	2.4	5.6
Cranhill Park	55° 51' 55.55"	-4° 9' 55.72"	10	17/06/2007	24.2	4.8	2.5
Crookston Woods	55° 50' 16.15"	-4° 20' 51.49"	10	09/07/2007	22.2	8.5	5.4
Dawsholm Park	55° 53' 48.65"	-4° 18' 57.62"	33	04/07/2007	24.3	17.8	8.0
Early Braes	55° 51' 5.64"	-4° 8' 9.41"	10	03/07/2007	20.7	4.6	26.9
Elder Park	55° 51' 48.51"	-4° 19' 19.24"	14	18/06/2007	32.4	3.8	129.0
Garscadden Burn	55° 54' 30.84"	-4° 21' 41.44"	23	19/06/2007	23.8	2.8	8.0
Garseadden Woods	55° 55' 9.96"	-4° 21' 26.53"	25	04/06/2007	16.4	7.1	18.5
Glasgow Green	55° 51' 5.25"	4° 14' 34.79"	53	08/07/2007	36.7	4.9	754.8
Hogganfield Park	55° 52' 47.17"	-4° 10' 4.35"	46	17/06/2007	16.6	12.5	40.7
Househill Park	55° 49' 13.64"	-4° 21' 45.20"	23	09/07/2007	18.2	8.8	5.6
Kelvingrove Park East	55° 52' 10.59"	-4° 16' 56.68"	36	18/06/2007	38.0	3.8	11.9
Kings Park	55° 48' 55.95"	-4° 14' 27.34"	28	08/07/2007	19.9	5.4	517.7
Knightswood Park	55° 53' 49.48"	-4° 21' 4.37"	20	04/07/2007	19.7	1.5	11.8
Linn Park	55° 48' 19.13"	-4° 15' 34.17"	50	11/06/2007	18.1	11.4	41.5
Maxwell Park	55° 50' 16.93"	-4° 17' 18.77"	8	10/06/2007	24.5	4.4	134.3
Mount Vernon Park	55° 50' 33.21"	-4° 8' 13.38"	6	03/07/2007	17.4	3.6	25.3
Newlands Park	55° 48' 43.51"	-4° 16' 56.04"	6	11/07/2007	23.3	2.0	84.1
Priesthill Park	55° 48' 39.19"	-4° 20' 45.65"	7	09/07/2007	24.2	7.3	8.0
Queens Park	55° 49' 49.00"	-4° 16' 13.88"	45	10/06/2007	30.7	7.2	129.1
Robroyston Park	55° 53' 24.23"	-4° 11' 44.30"	42	11/07/2007	18.9	2.9	163.4
Sandyhills Park	55° 50' 51.60"	-4° 9' 11.90"	9	03/07/2007	22.0	4.0	18.4
Springburn Park	55° 53' 32.17"	-4° 13' 22.65"	31	06/06/2007	22.7	7.8	49.1
Tollcross Park	55° 50' 56.35"	-4° 10' 49.95"	37	03/07/2007	28.1	7.1	23.8
Victoria Park	55° 52' 29.77"	-4° 20' 1.99"	20	04/07/2007	29.8	4.8	170.4

Table 1. Locations and attributes of parks visited and the landscape metrics used in the starting model of bat activity. [a] Mean Euclidean Nearest Neighbour Distance between water bodies (ENN distance is the shortest straight-line distance in metres between the focal patch and its nearest neighbour of the same class).

Source	Degrees of freedom	Parameter estimate	Estimate Standard Error	t value
Adjacent water	1	1.699	0.276	6.613 ***
Adjacent woodland	1	0.383	0.268	1.430 ***
Wind speed	1	0.389	0.260	1.496 ***
Temperature	1	-2.098	0.936	-2.242 ***
Temperature^2	1	0.058	0.0288	2.017 ***
Survey order	1	-0.207	0.103	-2.019 ***

Table 2. Generalised linear mixed-effects model for the effects of habitat and weather variables on bat activity within urban parks in Glasgow City (*** $p < 0.0001$). The sign and size of the parameter estimate (and the error) are used to assess the relative magnitude of the effects of these variables on bat activity.

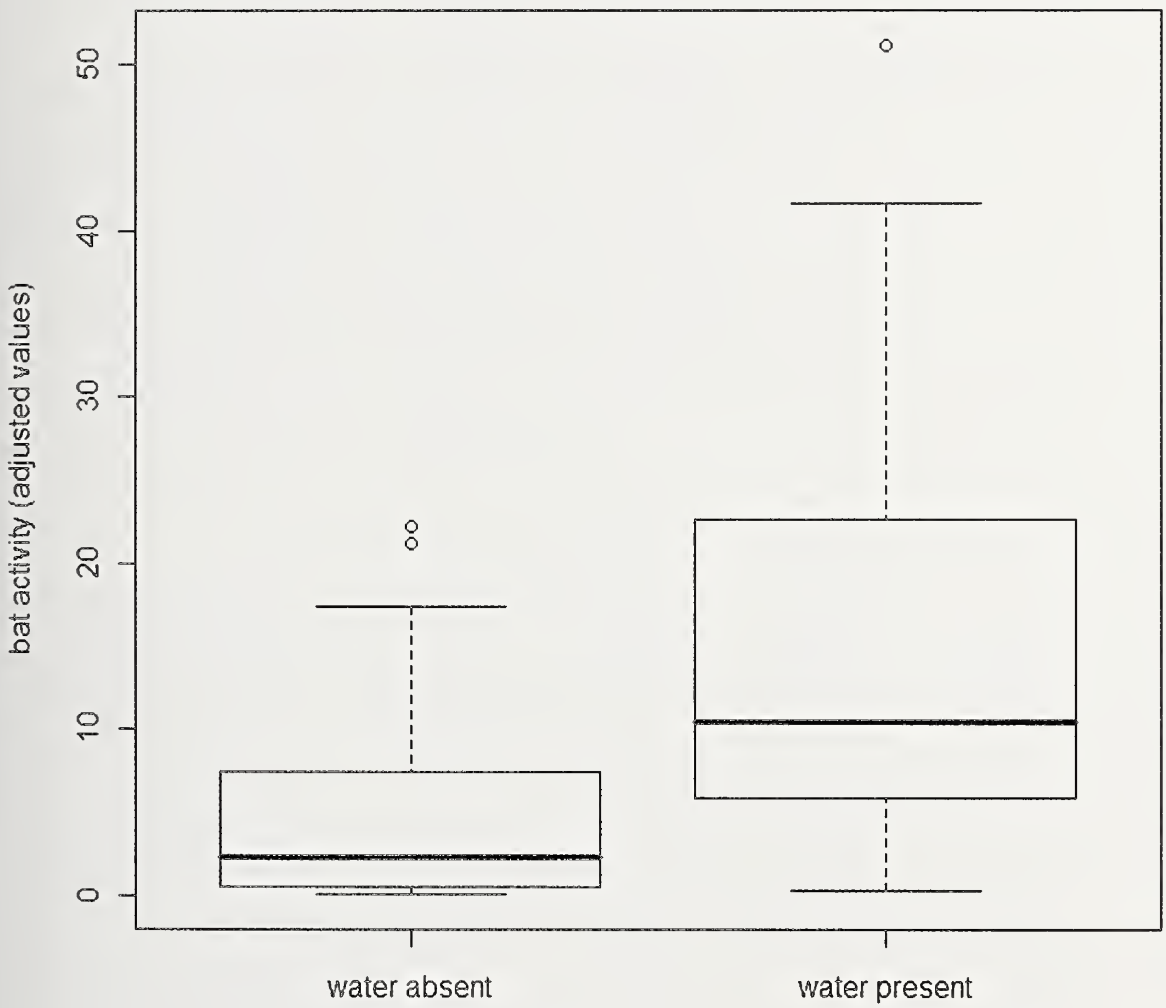

Fig. 1. Adjusted total bat passes at ten-minute point counts adjacent (n=31) and not adjacent (n=80) to water bodies. Values shown are those corrected for explanatory variables in the final model (Table 2). Tukey box plots are used here with boxes representing the location of the middle 50 percent of the data and the upper and lower quartiles, and the whiskers 1.5 x the interquartile range.

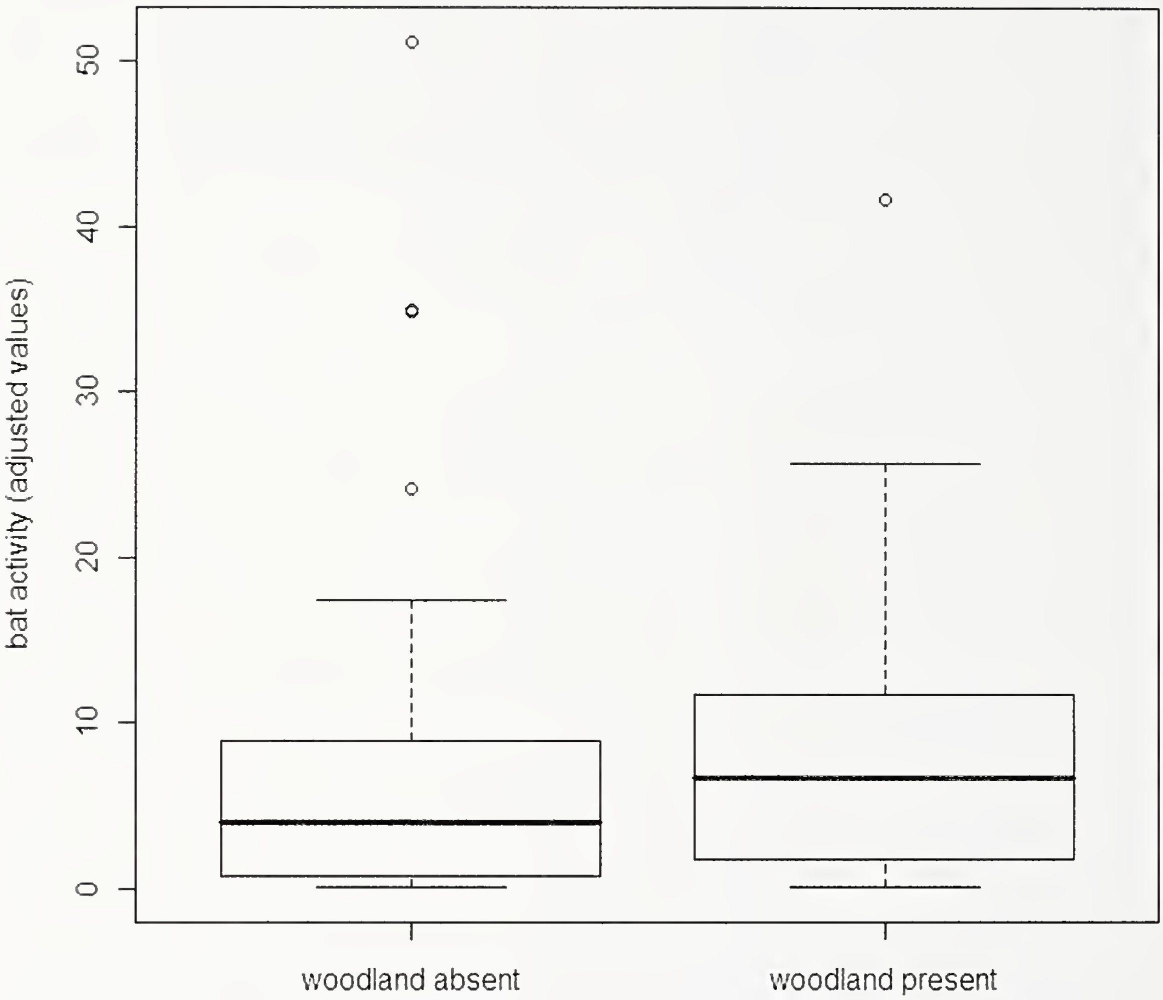

Fig. 2. Adjusted values of total bat passes at ten-minute point counts adjacent (n=50) and not adjacent (n=61) to woodland. Values shown are those corrected for explanatory variables in the final model (Table 2). Tukey box plots are used here with boxes representing the location of the middle 50 percent of the data and the upper and lower quartiles, and the whiskers 1.5 x the interquartile range.

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Urban Biodiversity: Successes and Challenges: Parklife; cities for people and nature

Scott Ferguson

Scottish Natural heritage

Some have argued that suburban gardens are England's most important nature reserve. Can that be true for Scotland too? From the butterfly on the buddleia to the raven nesting on the gas–tower, there is no doubt that the mosaic of habitats across urban areas support an amazing array of wildlife – and offer a wealth of opportunities for people to enjoy, learn about and celebrate that diversity.

Urban Biodiversity: Successes and Challenges: Cities deserve landscape-scale wildlife spectacles

Stuart Housden

Royal Society for the Protection of Birds Scotland

In such uncertain financial times it is heartening to recognise that the policy framework for delivering large scale habitat creation projects in Scotland has never been more positive. This is a recognition that these types of projects have been delivered elsewhere in the UK bringing with them not just a huge boost to biodiversity but a whole brigade of associated benefits.

Whether you are interested in education, climate change, flood alleviation, economic growth, creating a pleasant environment for people to live and work, direct employment or improving the social esteem of previously marginalised communities there is little doubt that investment in landscape scale environmental projects in an urban setting can and should make a significant contribution to the future of Scotland.

Urban Biodiversity: Successes and Challenges: A tactical approach

Malcolm Muir

Countryside and Greenspace Manager, South Lanarkshire council

The quality of urban open spaces can have a significant effect on their neighbouring communities. They offer opportunities for play, healthy recreation, sustainable transport and biodiversity and may indeed be the key to effecting a transformation in public understanding for and engagement with the natural heritage in Scotland. The eco–system approach rightly advocates acceptance of change, decentralisation and the participation of all sectors of society. Greenspaces, largely owned by Local Authorities offer the perfect test bed for this approach and the opportunity to clearly demonstrate to policy makers the links between environmental quality, health and economic and social well being. The current financial "crisis" actually presents a window of opportunity for this area of work but, despite these opportunities, real challenges remain; many of them linked to fundamental public service processes and "mind sets", and these will not be overcome through legislation alone.

Urban Biodiversity: Successes and Challenges: Glasgow's Freshwater Fishes – the State of the Cart (and other urban watercourses)

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The Clyde River Foundation (CRF) is a registered charity which researches the ecology of the River Clyde and its tributaries, and promotes environmental education throughout the catchment. Glasgow's freshwater fishes are surprisingly poorly known, despite the well–publicised renaissance of the local watercourses and the iconic nature of the salmon in Glasgow folklore. Our current knowledge of the fish communities of the major rivers: the Clyde, Kelvin, White Cart and North Calder will be described, together with a summary of the findings from a recent survey of Glasgow's burns.

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FULL PAPERS

From whaling to whale watching: a history of cetaceans in Scotland

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INTRODUCTION

Historic Utilization of Cetaceans

Scotland has over a thousand-year history of marine mammal exploitation dating back to the Stone Age. For example, cetacean bone was used as a building material in the wood-impoverished Orkney Islands; whale mandibles were used as rafters and in walls at the Neolithic site at Skara Brae in Orkney (Childe 1931). Sperm whale and bottlenose whale specimens were found at a Bronze Age site and sperm whale, minke whale, bottlenose whale and bottlenose dolphin artifacts have been found at a variety of Iron Age sites in South Uist (Mulville 2002). There is little evidence to suggest that these whales were butchered for food, but rather their bones used as building materials, turned into tools or utensils, and even burnt as fuel (Mulville 2002). Moreover a lack of harpoons or other tools to catch cetaceans suggest that these animals were stranded or very occasional catches rather than actively hunted (Mulville 2002).

Nordic occupation of the northern and western islands of Scotland in the early middle ages was particularly accompanied by marine mammal consumption and utilisation of stranded and hunted animals (Lindquist 1995) with remains of several cetacean species being found in Nordic sites in the Western Isles dating from the 9th century (Sharples 1997) to the 13th century (Brennand, Parker Pearson & Smith 1998). For example, on South Uist remains of pilot whale, bottlenose whale, killer whale, minke whale, sperm whale and even blue whale artefacts have been found at Norse archaeological sites (Mulville 2002). The larger number, diversity and probably age (many bones from young animals have been found) suggest that there may have been active hunting for cetaceans, although again there is no archaeological evidence of harpoons, nor any substantive evidence (from cuts on bones) of butchering cetaceans for meat (Mulville 2002).

In the northern and western Isles of Scotland, Norwegian laws on whale ownership and whaling held sway until at least 1611 (Ryder 1988). For example the *Gulathing* (mid 11thC) a law imported into Orkney presumably from Norway, has sections dealing with stranded whale ownership and distribution (Szabo 2005). In mediaeval Britain (early14th Century) cetaceans were made '*Fishes Royale*' by Edward III and any stranded cetaceans became property of the crown (Fraser 1977). A similar royal prerogative extended to Scotland, from at least 1603, but likely earlier (Erskine 1895). Despite this, local, subsistence, cetacean consumption continued in this region until at least the 18th Century as evidenced by this statement below:

"*...about one hundred and sixty little whales ran themselves ashore on the island of Tiree, and the natives did eat them all*" (Martin 1716).

Animals were also driven to the shore (Martin 1716) in a drive fishery akin to those seen today in the Faeroe Islands. Similar drive fisheries were conducted in the western and northern islands of Scotland until the early 20th century (Evans 1996).

CETACEANS AND SCOTTISH CULTURE

Cetaceans have been culturally significant in Scotland since at least the Iron Age, evidenced by carvings on standing stones that are believed to portray dolphins (Hicks 1996). This so-called "pictish beast", appears on 44 stones carved between 300 and 842AD. Macleod & Wilson (2001) took the issue one step further and suggested that the Pictish beast might represent a beaked whale. The distribution of these stones certainly coincides with the present day distribution of bottlenose dolphins in eastern Scotland being found in areas adjacent to the Moray Firth and along the coast of northeastern Scotland to Aberdeen.

The famous Scotland-dwelling Saint Columba is said to have warned monks travelling from the Isle of Iona to the Isle of Tiree of a "monster of the deep", which turned out to be "a whale of extraordinary size, which rose like a mountain above the water, its jaws open to show an array of teeth" (Sharpe 1995). This is not the

only link between one of Scotland's most famous religious figures and cetaceans, it's been suggested that due to a mistranslation the famous first recorded sighting of the Loch Ness monster (much vaunted by the Scottish tourist board), by said Saint may actually have been an encounter with a whale near the Moray Firth (Parsons 2004).

Folklore from the middle ages describes a sea unicorn from Scottish waters, the *Biasd na Srogaig* or beast with the lowering horn, which is most likely to have been sightings of narwhals, which could have ranged into Scottish waters during the cooler climates of the middle ages and renaissance (Parsons 2004). The unicorn was the Royal device of the Scottish kings since Robert III and it appears on the Scottish Royal crest (two unicorns originally, then one of the unicorns was replaced by a lion when James VI of Scotland inherited the English crown). Likewise the unicorn (and a Shetland pony) appears in the coat of arms of Shetland. It's been suggested that this heraldic device was influenced by Scotland's connection to narwhals (Buczaki 2002; Parsons 2004), and thus Scotland's cultural link to cetaceans is an important, if largely forgotten, one.

COMMERCIAL WHALING

Commercial whaling started in Scotland in Aberdeen in 1753, expanding to Dundee, Peterhead, Fraserburgh and Banff, on the east coast (O' Dell & Walton 1962). By 1820 there were 15 whaling vessels, but the whaling fleet then declined with only two vessels in 1838 (O' Dell & Walton 1962). These whaling operations were primarily to Arctic waters to pursue bowhead whales (Watson 2003). In 1882 a risky expedition was launched from Dundee to investigate whaling potential in Antarctica, an expedition that not only discovered Dundee Island (63°30'S 055°55'W), but also opened the possibilities of whaling in this region, although any increased industry was short lived as whaling from Dundee ended in 1912 (Watson 2003).

In 1903, coastal whaling stations opened in Scotland itself on Harris and the Shetland Isles – these stations caught cetaceans from Scottish wasters and operated until 1925. The Harris station was Norwegian owned until 1922, then purchased by Lord Leverhulme

"...partly to provide employment, but also because he suspected that the Norwegians were deliberately contaminating the herring-ground with whale offal to drive the herring to Norway." (Page 219 in Nicolson 1960)

The Harris station closed shortly after Leverhulme's death in 1925. The majority of the whale meat landed in Scotland was exported to Norway, although some was used as animal feed and fertilizer, and some was intended for export to Africa - there was no local consumption. The whale oil had been intended for soap production. The Harris station briefly reopened between 1950 & 1951, but commercial whaling from Scottish shores ceased after that. However, over 8,000 animals, from 7 species, were harvested from Scottish waters during this whaling period (Table 1; Thompson 1928; Brown 1976).

Species	Number taken
blue whales	401
fin whales	6074
right whales	100
humpback whales	70
sei whales	2214
sperm whales	96
northern bottlenose whales	26

Table 1. Cetaceans taken in Scottish whaling operations (Thompson 1928; Brown 1976).

TODAY – MARINE MAMMAL TOURISM

Today, Scottish cetaceans are still an economic resource, albeit they are no longer killed – via whale watching. The main whale watching areas are currently western Scotland, especially the Isle of Mull and the Small Isles, Inverness and the Moray Firth and the Orkney and Shetland Islands. Target species are predominantly bottlenose dolphins, minke whales and harbour porpoises (Hoyt 2001; Parsons et al. 2003; Warburton et al. 2001). In 2000, in a survey marine wildlife tour operators, 47% surveyed consider whale-watching to be important to local economies (Warburton et al. 2001).

It was estimated that in 2000 the Scottish cetacean tourism was worth at least £10.7 million (US$18 million) (Warburton et al. 2001; Parsons et al. 2003), of £7.8 which million was from the West Coast of Scotland alone.[4] Moreover, in some remote coastal areas, cetacean-related tourism may account for as much as 12% of the area's total tourism income which is substantial when one bears in mind that tourism is Scotland's number one industry, is a major employer in rural areas particular in rural areas, and thus an important economic activity in these marginal regions in particular (Parsons et al. 2003).

More recent figures for the total value of the Scottish cetacean tourism industry as a whole are not available, but in the Moray Firth, on the east coast of Scotland, the value of dolphin-watching has increased

[4] For comparison, at the time of the study, Norwegian commercial whaling worth $6 million (Toolis 2001) and that value incorporated heavy subsidising by the Norwegian government.

substantially over the past decade: in 1998 Hoyt (2001) estimated that in total cetacean tourism in the Moray Firth attracted generated £0.48 million from trip expenditure and £2.34 million in total expenditure (when one includes expenditure on accommodation etc.); but a more recent study from 2009 (albeit using a different methodology) estimated that total direct expenditures related to the dolphin population in the Moray firth were at least £10.4 million (Davies et al. 2010). One would assume that over the past decade, the value of cetacean tourism has generally increased across Scotland, not just in the Moray Firth.

The whale watching industry is generally considered to be economically viable in the long-term (Woods-Ballard et al. 2003), appears to provide employment particularly for those working in the declining sectors of farming and fishing (Woods-Ballard et al. 2003) and the industry could have considerable potential for further development (Howard & Parsons 2006a) if developed responsibly. Although there are some concerns, most whale watching operators in Scotland seem to be accepting of the need to follow whale watching guidelines or codes of conduct (Parsons & Woods-Ballard 2003). In fact, it is probably in the best interests of whale watching operators to be as responsible and environmentally sustainable as possible as whale watching tourists tend to be environmentally motivated, displaying a high degree of environmental participation (Rawles & Parsons 2004).

Surveys in Scotland's main cities of Glasgow and Edinburgh, members of the public seemed to be aware of the opportunities for whale watching in Scotland, especially in areas such as the Moray Firth (Howard & Parsons 2006a). This high level of awareness is remarkable when one considers that the first commercial Scottish whale watching trip was in 1989, and with only one commercial operator in 1994 (Hoyt 2001; Parsons et al. 2003). Part of the recent surge in awareness of the whale watching industry may be in part due to TV nature programmes (such as *Springwatch* and *Countryfile*) that frequently feature whale watching and cetaceans, and the marketing efforts of new operator associations such as *Wild Scotland* (http://www.wild-scotland.org.uk/).

PUBLIC AWARENESS OF CETACEANS

There have been several studies in Scotland to ascertain public awareness of cetaceans and their conservation. For example, Scott & Parsons (2004) interviewed members of the public in southwestern Scotland finding that few people were aware of the diversity of cetacean species in the waters of this region (24 species; Shrimpton & Parsons 2000), although over twice as many gave the correct answer in rural regions as opposed to urban areas (4.4% vs. 1.9% in rural areas and cities, respectively; Scott & Parsons 2004). When asked is specific species occurred in Scottish waters, members of the public fared better with 56.7% being aware of bottlenose dolphins, 50% harbour porpoises, but o 22.6% for killer whales, 14.7% for Risso's dolphins and only 39.3% knew of the minke whale, the most common baleen whale species in Scottish waters (Scott & Parsons 2004). Younger participants (18-30), residents of the Isles of Mull and Islay (whale watching areas), people who took part in marine activities and members of environmental groups scored significantly higher than other participants (Scott & Parsons 2004). When asked to identify photographs of common species, only 17.5% could identify a harbour porpoise (19% bottlenose dolphins; 10.7% minke whale and 7.1% common dolphin; Scott and Parsons 2004). Those sectors of the public who were more aware of the occurrence of cetaceans also could identify them, but city dwellers and interestingly workers in fishing, tourism and education sectors were less able to identify species (Scott & Parsons 2004).

AWARENESS OF CONSERVATION ISSUES

With respect to threats to cetaceans in Scotland, members of the public tended to be more concerned about impacts of factors such as sewage pollution, marine litter, over-fishing and oil spills, i.e. relatively visible issues (Scott & Parsons 2005; Howard & Parson 2006b). A survey of cetacean experts was also conducted to ground truth the public perceptions and it was found that these experts were more concerned about climate change, whale-watching, military activities and dredging (i.e. issues mostly relating to noise and disturbance) than the general public, but they were less concerned about oil spills and sewage pollution (Howard & Parsons 2006b). In general, the majority of the public questioned who had an opinion, stated that they did not think cetaceans were sufficiently protected in Scotland (Table 2), although there was a high proportion of those from cities who stated that they didn't know whether they did or not (Scott & Parsons 2005; Howard & Parsons 2006b).

How well are Cetaceans protected?	Percentage (South-west)	Percentage (Major cities)
Don't Know	25.8 %	60.0 %
Over-protected	0.4 %	0.0 %
Sufficiently protected	28.2 %	7.0 %
Not sufficiently protected	45.6 %	33.0 %

Table 2. Public attitudes to how well cetaceans are protected in Scotland (Scott & Parsons 2005; Howard & Parsons 2006b).

However, when asked whether laws should be introduced specifically for the conservation of

cetaceans in Scotland (e.g., a Cetacean Protection Act for Scotland): 80% supported such a piece of legislation. Moreover, when asked if a politician were to introduce such a law would it make them see the politician more favourably 40% said yes it would make them view that politician in a better light (26% were unsure; Howard & Parsons 2006b). It is interesting to note that after these surveys were publicized, for the first time, all of the major political parties specifically mentioned cetacean conservation in their next election manifestos.

PUBLIC ATTITUDES TO WHALING

Going from a nation which conducted whaling historically and also as a commercially for nearly two hundred years, the public seems to now be greatly opposed to this activity, with a survey conducted in 2001 finding that 96.4% of the public were opposed to whaling (75% strongly opposed; 2.4% did not know; Scott & Parsons 2005). Moreover, 79% of whale-watchers in Scotland stated in a survey that they would boycott visiting a country that conducted hunts for cetaceans, such as Iceland, Japan or Norway (Parsons & Rawles 2003), This illustrates a dramatic sea change in attitudes to cetaceans nearly fifty years after whaling stopped in Scottish waters, arguably because of the people of Scotland appreciate the cultural and economic value of living cetaceans in their waters.

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The moth assemblage of Flanders Moss, Stirlingshire

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ABSTRACT
Moth records derived from an extensive programme of trapping between 2004 and 2010 have been combined with older data-sets in an assessment of the moth assemblage of Flanders Moss. Of the 282 moths species recorded, 45 are considered rare, scarce or local in Great Britain. Other species are present that have dramatically declined in their UK-wide abundance.

INTRODUCTION
The peat dome that forms the raised bog of Flanders Moss was once part of one of the largest complex of raised bogs and other wetland habitats found in the UK. Dotted along the former post ice age estuary of the Carse of Stirling they were subject to clearance and drainage and today Flanders Moss is only 60% of its original size while some other raised bogs on the Carse were completely cleared. Nevertheless, Flanders Moss, lying between Thornhill to the north and Kippen to the south, remains the biggest raised bog in the UK and one of the most important in western Europe. Lowland raised bogs tend to have a richer fauna and flora than upland blanket bogs and that of Flanders Moss is of national importance; hence it has been designated an site of Special Scientific Interest (SSSI), Special Area of Conservation (SAC) and National Nature Reserve (NNR). This paper presents a compilation of the moth assemblage of the Moss that is based on an extensive programme of recording from 2004 to 2010 but also includes older data-sets.

METHODS
Moth traps were run in various parts of the Flanders Moss NNR between 2004 and 2010. A Robinson 125w MV trap and one or two Heath actinic traps were operated by Scottish Natural Heritage (SNH) staff members, Leigh Marshall and David Pickett. The author assisted with the identification of the catch. Key trapping locations were chosen to include the open moss of the raised bog, habitats dominated by bog myrtle (*Myrica gale*) and the fringing birch wood.

The data derived from moth trapping has been combined with the data-sets of Bland (1988 and 2003); Christie (1986), Maclaurin (1974), Morris (1991), Palmer (1986) and a Scottish Entomologists weekend in 1989. Most, perhaps all, of these came from day-time observations and were thus dominated by day-flying moths and species that were identified from their larvae or evidence of larval feeding such as leaf-mines. Other day-time observation records from visitors to the NNR and Scottish Wildlife Trust (SWT) reserves are included where these have been submitted to and validated by the author in his capacity as vice county moth recorder.

RESULTS
Table 1 lists 282 moth species recorded on Flanders Moss up to October 2010. The "code" column gives the UK checklist number (Bradley, 2000). The "records" column lists the number of times that each species has been recorded. It is not possible to list the number of individuals that have been recorded as not all recorders have collected this data. The status column indicates the UK national status of each macro moth species as defined by the Joint Nature Conservation Committee. The categories are as follows:

Red Data Book species (RDB) - species known from 15 or less 10km squares in the UK.
Proposed RDB (pRDB) – proposed for inclusion in the next Red Data Book listing because current information indicates that the species meets the criteria.
Nationally Scarce A (Na) - species recorded from 16-30 10km squares since January 1980.
Nationally Scarce B (Nb) - species recorded from 30-100 10km squares since January 1980.
Local - species recorded from 100-300 10km squares since January 1980.
Common - species recorded from over 300 10km squares since January 1980
Uncommon on introduced food-plant.
Immigrant.
Rare immigrant.
Import.

Of the moth families collectively known as micros, the Pyralidae have also been given UK national status rankings but, of the remaining micro moth families, only those species worthy of Nationally Scarce or Red Data Book status have been categorised.

A list of butterflies and moths from Flanders Moss, published by Maclaurin (1974), included nine larger moth species not otherwise recorded on the Moss and not included in Table 1. They are ghost moth (*Hepialus humuli*), shaded broad-bar (*Scotopteryx chenopodiata*), yellow shell (*Camptogramma bilineata*), grey mountain carpet (*Entephria caesiata*), juniper carpet (*Thera juniperata*), small yellow wave (*Hydrelia flammeolaria*), tawny-barred angle (*Macaria liturata*), dotted border (*Agriopis marginaria*) and Scotch annulet (*Gnophos obfuscatus*). Dotted border flies at a time of the year when there has been little investigation of the moth fauna of the Moss and its presence would not be unexpected. The larvae of tawny-barred angle feeds on various conifers and the moth was recorded when there were more conifers on the Moss. However, other species on this list, including the nationally scarce, scotch annulet, would not be expected on Flanders Moss. Similarly, juniper carpet is unlikely as its foodplant, common juniper (*Juniperus communis*), has never been recorded on the Moss. It appears possible that Maclaurin may have included a wider spectrum of habitats in his paper than are considered a part of Flanders Moss in this assessment (no precise locations, observational methods or dates are given in the paper). It therefore appears safest to exclude these nine species from the Flanders Moss data-base.

Common rustic (*Mesapamea secalis*) and lesser common rustic (*Mesapamea didyma*) were only recognised as separate species in 1983 and can only be separated by examination of their genitalia. This has not been done on specimens from the Moss so the records are aggregated as (*Mesapamea secalis agg*). Elsewhere in west central Scotland the two species occur in roughly equal numbers.

The ear moths (*Amphipoea*) comprise another genus that can only be unambiguously identified by examination of their genitalia. In August and early September, large numbers of *Amphipoea* come to light traps on the Moss. All of those that have been dissected have proved to be large ear (*A. lucens*); the remainder have been recorded as *Amphipoea oculea agg.* Based on records from elsewhere in the area, almost all of these will be large ear but low numbers of Crinan ear (*A. crinanensis*) might be expected.

DISCUSSION

Of the 282 moths species recorded on Flanders Moss, 45 have received a UK national status of pRDB, Nationally Scarce or Local.

MOTHS CLASSED AS pRDB

One pRDB moth occurs on Flanders Moss

Lampronia fuscatella - This scarce micro-moth occurs in widely scattered localities throughout the UK and its provisional Red Data Book status of 3 indicates that it is vulnerable. It occurs only in regenerating birch woodland on raised peat and is characteristic of ancient birch woodland with a continual history of regeneration. The larvae form galls in the twigs of downy birch (*Betula pubescens*), usually at a node of twigs that are 3 – 13 mm in diameter and 1.0 to 1.5 m from the ground on trees less than 10 years old. The larva within the gall is fully grown in May when it makes a hole to the exterior which it caps with silk and frass. It then pupates in the gall and emerges in June. Records from Flanders Moss indicate that the species is heavily parasitized.

MOTHS CLASSED AS NATIONALLY SCARCE A (Na)

Two Na moths occur on Flanders Moss

Rannoch brindled beauty *(Lycia lapponaria)* - The Rannoch brindled beauty is a moth of boggy acid moorland and in the UK its distribution is centred on the central highlands; particularly Rannoch and upper Speyside. Flanders Moss is the most southerly known site for the species and is well separated from other known locations. Although it has been found to feed on a range of moorland plants including heathers (*Calluna vulgaris* and *Erica* sp.), bilberry (*Vaccinium oxycoccus*) and eared sallow (*Salix aurita*), the occurrence of the species is strongly associated with its main foodplant, bog myrtle (*Myrica gale*). The moth is most easily found as an adult during late March and April by daylight searching of fence posts, old tree stumps and the trunks of trees growing close to bog myrtle. Both sexes rest on these sites and females lay eggs into crevices in them (personal observations of the author) as well as in the dead corollas of cross-leaved heath (*Erica tetralix*) (South,1908). Using this search method, males and females can be found on all those areas of the moss where bog myrtle grows including western fragments between the A81 and B8034 (Offerance Moss) that are outside the nature reserve. Limited data gained by searching the same areas every year indicate a fairly stable population of the moth but more organised observation over many more years would be necessary to confirm this.

Great brocade (*Eurois occulta*) - Throughout most of the UK the great brocade occurs uncommonly and irregularly as an immigrant from northern Europe. These immigrant moths are predominantly mid-grey in colouration. However, there is also a scarce resident form of the moth in the central and western highlands of Scotland that is blackish, variably marbled with grey. Occasional records from Flanders Moss appeared to be of this form and in March 2007 the author swept larvae from the catkins of bog myrtle proving that the species breeds on the moss. Subsequently, a single Robinson trap placed near the same area of bog myrtle on 22nd July 2010 caught five adults, all of which appeared to be freshly emerged. Bretherton *et al* (1983) state that resident populations are found close to growths of bog myrtle; especially where these are bordered by trees. This exactly fits the location in which larvae were found on Flanders Moss and where five adults were subsequently caught in a single overnight trap. There seems every reason to assume that there is a resident population on Flanders Moss

MOTHS CLASSED AS NATIONALLY SCARCE B (Nb)

Nine species of moth recorded on the Moss have Nb status.

Atemelia torquatella - A northern species in the micro moth family Yponomeutidae. The larvae forms blotch leaf-mines in regenerating birch.

Biselachista serricornis – A leaf-mining species in the micro-moth family Elachistidae. It has a scattered distribution that includes central Scotland and it inhabits boggy areas and damp shady woods where the foodplant wood sedge (*Carex sylvatica*) grows. On Flanders Moss this is largely at the fringes.

Bryotropha boreella – A rare and local member of the micro-moth family Gelechiidae that is found on heather (*Calluna vulgaris*). The single record for this species on the Moss is hard to assess and requires confirmation.

Bryotropha galbanella - A local member of the micro-moth family Gelechiidae that is found in forested areas and feeds on mosses.

Prolita sexpunctella - A local member of the micro-moth family Gelechiidae that is found on heaths, moors and mosses and is often seen flying over burnt patches of regenerating heather. The larvae feeds within the spun leaves of heather

Argent and sable (*Rheumaptera hastata*) - In central Scotland, the argent and sable is best known from Flanders Moss where it occurs in most areas of what is now a fragmented habitat; including Offerance Moss. It is also regularly recorded from Glen Finglas, was known historically in the area of Loch Venachar and probably awaits discovery in other areas where bog myrtle is abundant. There is considerable confusion over the various forms of this moth. Most sources state that the southern form *hastata* occurs up to the southern uplands of Scotland and feeds on young birch while the smaller, more intricately marked northern form *nigrescens* feeds on bog myrtle. The moths on Flanders Moss most resemble the form *hastata* despite the fact that their larvae are found mainly on bog myrtle on which they form characteristic domed tents comprising the terminal leaves of young shoots. Most commonly they are on dense, tall plants (0.8 – 1.2m) where bog myrtle is the dominant vegetation often close to birches. There is just one record of a larva feeding on birch on Flanders Moss. The argent and sable has UK Biodiversity Action Plan (BAP) status and is a UK priority species with published action plans (Department of the Environment, Transport and Regions 1999, Kinnear and Kirkland, 2000).

Manchester Treble-bar (*Carsia sororiata*) - Manchester treble-bar is a moth of wet moorland, mosses and bogs. It is confined to northern England and Scotland where it is widespread but scarce. On Flanders Moss it is common and, during July and August, is readily disturbed from ground vegetation during the day. It is also recorded in light traps. The species is much less common elsewhere in central Scotland with widespread but only occasional records. The larvae feed on bilberry, crowberry (*Empetrum nigrum*) and cranberry (*Empetrum oxycoccus)* and it seems likely that the moth will continue to flourish as long as its open boggy habitat is preserved.

Silvery arches (*Polia trimaculosa*) - Although recorded from heaths and mosses throughout the UK, the main centres of distribution of silvery arches are the river valleys of the Spey, Rannoch, Dee and Clyde. There are only five records from Flanders Moss but four of these were in a single trap near bog myrtle and birches on 18th June 2010. The main larval foodplants are bog myrtle, birches and sallow and the western parts of the NNR would appear to offer excellent habitat for this species. Although it comes to light traps in small numbers it is more strongly attracted to sugar. The author is unaware of any sugaring on the moss but it may prove rewarding.

Marsh oblique-barred (*Hypenodes humidalis*) - Because it is small and easily confused with a micro-moth, the marsh oblique-barred is often overlooked. Its habitat requirements are bogs, boggy moorland, swamps, water meadows and marshes and its known foodplants include cross-leaved heath and sphagnum mosses. Christie (1986) recorded it as occurring in 'a very extensive and very numerous colony on the Moss'. However, it was only recorded once more before 2010 when on 11th August, ten were found in a single overnight trap. It appears likely that the moth remains much more common than the few records suggests.

MOTHS CLASSED AS LOCAL

Thirty three moth species classed as local have been recorded on Flanders Moss. Although they are all listed below, not all can be regarded as important members of the Flanders Moss moth assemblage; the species accounts indicate those that are.

Gold swift (Hepialus hecta) – There are few records of gold swift from Flanders Moss and it is most likely to be encountered around its fringes where the larval foodplant bracken (*Pteridium aquilinum*) grows. It cannot therefore be regarded as a key member of the moth assemblage.

Map-winged swift (*Hepialus fusconebulosa*) – Although nationally local, this species is the most common member of the genus in west central Scotland and its presence on Flanders Moss is unremarkable. Like the above species it is likely to be commonest around its fringe where the main larval food plant, bracken, grows.

Pearl-band grass veneer (*Catoptria margaritella*) – This species can be abundant on Flanders Moss and is a part of the resident moth assemblage. Although classed as local, it can be common on boggy moorland throughout Scotland.

Orange underwing (*Archiearis parthenias*) - The orange underwing is not an easy moth to see in central Scotland. It flies in sunshine in late March and April around the tops of birches growing on moorland and other open environments. Less often it can be seen feeding on sallow catkins and is sometimes found on the ground basking or drinking from puddles. It is never common and persistence is required to see it

well. The mature birches around the edge of Flanders Moss are productive places to look for it.

Smoky wave (*Scopula ternata*) - Although smoky wave is found on moorland and lightly wooded heath throughout central Scotland it is particularly abundant on Flanders Moss. During June and July large numbers can be disturbed when walking across the more open parts of the Moss. The larvae feed on heather and bilberry.

Plain wave (*Idaea straminata*) – The habitat preferences of this uncommon species are open woodland and scrubby heaths. Despite the fact that it does not appear ideal for the species, a high percentage of the historical and recent records from central Scotland come from Flanders Moss. Care must be taken with the identification of the species as it is easily confused with the very common riband wave (*Idea adversata*).

Ling pug (*Eupithecia absinthiata f. goossensiata*) – ling pug is a local, heather-feeding form of wormwood pug (*Eupithecia absinthiata*) which is a common polyphagic species. Separation of the two forms is somewhat subjective but, surprisingly, there appear to be no records of wormwood pug from Flanders Moss and there are just two records of ling pug.

Shaded pug (*Eupithecia subumbrata*) – A single example of this species in a light trap run on the moss on 18th June 2010 was the first record from central Scotland since 1987 and the first known record from either Flanders Moss or vice county 87. The normal habitat of the species is rough grassland and it is most common in southern England on chalk downs and in the Brecks. However, it is found locally in parts of western Scotland (Riley and Prior, 2003) and three specimens in the collection of the late Iain Christie were caught at Conie Hill in 1981 and near Gartocharn in 1987. Thus, the species is not unknown in the area and it is highly desirable to try to discover if it is a resident member of the moth assemblage of Flanders Moss.

Lunar thorn (*Selenia lunularia*) – Although never very common, in central Scotland this species occurs in woodland, parks and gardens as well more open habitats like Flanders Moss. It is not therefore one of the more important members of the moth assemblage of the site. The larvae feed on the leaves of a range of broad-leaved trees which on the Moss will be mainly birch.

Grey scalloped bar (*Dyscia fagaria*) – This local species of moors, bogs and mosses should be regarded as an important member of the Flanders Moss moth assemblage. All but three of the known records from central Scotland come from the site. The larvae feed on heathers and the moth appears to prefer the short swards that are typical of many open areas of the Moss. Grey scalloped bar is a UK species of conservation concern and is the subject of a south-west Scotland regional action plan (Kinnear and Kirkland, 2000).

Grass wave (*Perconia strigillaria*) – Although grass wave has been recorded from several moorland sites in the Loch Lomond basin, it is only common on raised bogs and mosses. Like the above species, it is an important member of the Flanders Moss moth assemblage.

Small elephant hawk moth (*Deilephila porcellus*) – This species has been recorded in increased numbers in central Scotland over the last 10 years and Flanders Moss is one of many habitats in which it has been observed. It is not considered a key member of the moth assemblage of the site.

Dark tussock (*Dicallomera fascelina*) – Dark tussock is regularly recorded on Flanders Moss as adults and larvae and the species is a part of the resident and breeding moth assemblage. However, it is also found on moorland throughout Scotland as heather is the main larval foodplant.

Round-winged muslin (*Thumatha senex*) - A single example of this species in a light trap run on the moss on 18th June 2010 was the first record from central Scotland since 1991. Nevertheless, this is a moth of wet moorland, bogs and flushes and it appears highly likely that there is a resident if small population on the Moss. It is clearly desirable to confirm whether this is the case.

Red-necked footman (*Atolmis rubricollis*) - During the first decade of the 21st century, this species has spread spectacularly northwards through central Scotland and beyond (Knowler, 2010). Particularly high numbers are found in association with sitka spruce (*Picea sitchensis*) and it is likely that all records on Flanders Moss are of moths that have come from neighbouring spruce plantations. The species is likely to continue to be recorded on the Moss but it is not considered a key member of its moth assemblage.

Four-dotted footman (Cybosia mesomella) – Although the four-dotted footman is widely distributed on heaths, moorland and bogs, it is particularly common on Flanders Moss. It is frequently disturbed from ground vegetation during the day and overnight catches of up to 66 have been recorded in single light traps. The larva feeds on lichens (*Cladonia sp.*) growing on heathers and these are abundant throughout open areas of the Moss.

Wood tiger (*Parasemia plantaginis*) – Like the above species, wood tiger is widespread but local on moorland and bogs. There is healthy population on Flanders Moss. Although larvae have been observed on various herbaceous plants, heathers are the main foodplants and this is assumed to be the case on the Moss. As long as open areas of the moss do not become overgrown the population of this species is likely to be secure.

Clouded buff (*Diacrisia sannio*) – Like the above two species, clouded buff is strongly associated with moorland and bogs and there is a particularly strong population on the Moss. During the flight season, multiple adults are likely to be disturbed from the vegetation during a walk over the moss and up to 20 have been recorded in and around a single overnight light trap. The larvae feed on heathers and other herbaceous moorland plants.

Neglected rustic (*Xestia castanea*) – The neglected rustic is found on moorland, raised bogs and in woodland with heather in the understory. The colour

form with buff, pink-edged forewings is regularly recorded on Flanders Moss. Larvae feed on heather, bell heather (*Erica cinerea*) and cross-leaved heath. UK-wide this species decreased by 82% between 1968 and 2002 (Fox *et al*., 2006).

Heath rustic (*Xestia agathina*) – The heath rustic is a local moth of acid heaths, moorland and bogs but is particularly common on Flanders Moss. Thus, 77 were recorded in a single trap on 6th September, 2007. The larvae feed on heather. UK-wide this species decreased by 84% between 1968 and 2002 (Fox *et al*., 2006).

Beautiful brocade (*Lacanobia contigua*) – The beautiful brocade is an uncommon moth of lightly wooded moorland and a high percentage of records from central Scotland come from Flanders Moss. The larvae feed on birches, oaks and other woody species so the species is presumably dependent on areas of birch on the Moss.

Glaucous shears (*Papestra biren*) – Although classed as nationally local, glaucous shears occurs on moorland throughout Scotland and is an expected part of the Flanders Moss moth assemblage.

Golden-rod brindle (*Lithomoia solidaginis*) – Despite occurring widely on the moorlands of Scotland, golden-rod brindle is an uncommon moth. Most recent records from central Scotland are from Flanders Moss. The larvae have been recorded from heathers, bilberry, bog myrtle and other moorland plants.

Red sword-grass (*Xylena vetusta*) – The main habitat of this uncommon species is moorland and rough upland grassland and it would be expected to be an integral part of the moth assemblage of Flanders Moss. However, it also occurs in damp woodland and marshes and is regularly recorded in light traps in parkland and gardens near suitable habitat. Any specimen should be carefully examined to exclude the very similar and nationally scarce sword-grass (*Xylena exsoleta*) which is unrecorded on the Moss but could occur.

Suspected (*Parastichtis suspecta*) – Throughout much of Scotland, suspected is a widespread but uncommon moth of fens, car and moorland with birch scrub. It is an integral component of the Flanders Moss moth assemblage. The larvae feed on the terminal shoots of scrub birch.

Light knot-grass (*Acronicta menyanthidis*) – An uncommon moth of the damper parts of moors and bogs, light knot-grass is typical part of the moth assemblage of Flanders Moss. As well as coming to light traps, it is often found resting on fence posts. The larvae feed on woody moorland plants including bog myrtle, heathers and bilberry.

Old lady (*Mormo maura*) – The old lady is an uncommon moth of riverbanks, marshes, gardens and hedgerows and the single record from Flanders Moss was at its edge. Thus, the species should not be regarded as a typical member of the moth assemblage of the Moss.

Large ear (*Amphipoea lucens*) – Although nationally local, the large ear is the commonest member of the genus throughout central Scotland. Single overnight trap catches of over 50 *Amphipoea sp*. have been recorded on Flanders Moss and all of those unambiguously identified by examination of the genitalia have proved to be this species.

Haworth's minor (*Celaena haworthii*) – As a moth of bogs and boggy moorland, Haworth's minor is an integral part of the moth assemblage of Flanders Moss. Its larvae feed on common cotton grass (*Eriophorum angustifolium*). UK-wide this species decreased by 89% between 1968 and 2002 (Fox *et al*., 2006).

Crescent (*Celaena leucostigma*) – Although not as tied to boggy moorland as the previous species, the crescent is nevertheless an integral part of the moth assemblage of Flanders Moss. In this habitat its larvae probably feed on purple moor-grass (*Molinia caerulea*). UK-wide this species decreased by 82% between 1968 and 2002 (Fox *et al*., 2006).

Lempke's gold spot (*Plusia putnami gracilis*) – The common species, gold spot (*Plusia festucae*), and the more local Lempke's gold spot both occur on the moss and their separation can be challenging. Lempke's gold spot is a more northern species and is not uncommon in damp habitats throughout central Scotland.

Scarce silver Y (*Syngrapha interrogationis*) – Although there is only one record of this uncommon moorland species from Flanders Moss it appears likely that it is a scarce breeding resident and therefore an integral part of the moth assemblage. Its larvae feed on heather and bilberry.

Pinion-streaked snout (*Schrankia costaestrigalis*) – A single specimen in a light trap on 22nd July 2010 appears to be the only record of this species from Flanders Moss. This is surprising as it is a moth of damp habitats including raised bogs. However, the lack of earlier records may reflect the ease with which this micro-like species can be over-looked.

MOTHS OF FLANDERS MOSS THAT HAVE DRAMATICALLY DECLINED IN THEIR UK ABUNDANCE

Fox *et al*. (2006) analysed thirty five years of data from the UK-wide network of Rothamsted light traps during the period 1968 to 2002. They examined the data for 337 species of common larger moths and showed that two thirds (226 species) had declined in abundance and 75 species had decreased by over 70% over the thirty five years. 14 of these are found on Flanders Moss and they are listed in table 2 in order of their percentage change in UK abundance. International Union for Conservation of Nature (IUCN) categories are based on rate of decline.

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Code	Taxon	Vernacular	Records	First Recorded	Last Recorded	UK Status
3	*Micropterix aureatella*		2	1991	2005	
14	*Hepialus humuli*	Ghost Moth	1	2004	2004	Common
16	*Hepialus hecta*	Gold Swift	4	1973	1991	Local
17	*Hepialus lupulinus*	Common Swift	1	2004	2004	Common
18	*Hepialus fusconebulosa*	Map-winged Swift	9	1973	2010	Local
34	*Ectoedemia occultella*		3	1989	1989	
66	*Stigmella sorbi*		3	1989	1989	
103	*Stigmella nylandriella*		3	1989	1989	
112	*Stigmella luteella*		4	1989	1989	
116	*Stigmella lapponica*		4	1989	1989	
117	*Stigmella confusella*		3	1989	1989	
129	*Incurvaria pectinea*		2	1988	1989	
138	*Lampronia fuscatella*		3	1988	2006	pRDB3
140	*Nematopogon swammerdamella*		2	2005	2005	
141	*Nematopogon schwarziellus*		1	1988	1988	
157	*Heliozela hammoniella*		4	1989	1989	
186	*Psyche casta*		3	1988	1989	
216	*Nemapogon cloacella*	Cork Moth	1	1986	1986	
228	*Monopis weaverella*		2	1986	1988	
276	*Bucculatrix demaryella*		1	1988	1988	
300	*Parornix loganella*		1	1991	1991	
301	*Parornix betulae*		3	1986	1989	
305	*Parornix scoticella*		1	1988	1988	
324	*Phyllonorycter sorbi*		3	1989	1989	
332	*Phyllonorycter corylifoliella f. betulae*		2	1989	1989	
338	*Phyllonorycter cavella*		2	1989	1989	
347	*Phyllonorycter anderidae*		3	1989	1991	
353	*Phyllonorycter ulmifoliella*		3	1988	1989	
385	*Anthophila fabriciana*		1	2005	2005	
391	*Glyphipterix simpliciella*	Cocksfoot Moth	1	2005	2005	
395	*Glyphipterix haworthana*		2	1988	1989	
410	*Argyresthia brockeella*		1	1988	1988	
411	*Argyresthia goedartella*		2	1986	1986	
415	*Argyresthia retinella*		2	1986	1986	
418	*Argyresthia conjugella*	Apple Fruit Moth	1	1988	1988	
437	*Swammerdamia caesiella*		3	1988	1989	
442	*Cedestis gysseleniella*		1	1986	1986	
443	*Cedestis subfasciella*		1	1986	1986	
444	*Ocnerostoma piniariella*		1	1986	1986	
448	*Atemelia torquatella*		2	1989	1989	Nb
452	*Ypsolopha nemorella*		1	1983	1983	
460	*Ypsolopha parenthesella*		3	1986	1988	
464	*Plutella xylostella*	Diamond-back Moth	3	1986	1989	Migrant
493	*Coleophora serratella*		7	1983	2006	
496	*Coleophora milvipennis*		3	1988	1989	
504	*Coleophora lusciniaepennella*		3	1988	2005	
504	*Coleophora viminetella*		2	1983	1986	
541	*Coleophora pyrrhulipennella*		3	1988	1989	
608	*Elachista rufocinerea*		1	1991	1991	
621	*Elachista subalbidella*		1	1988	1988	
626	*Biselachista serricornis*		1	1988	1988	Nb
630	*Biselachista albidella*		1	1986	1986	
654	*Pleurota bicostella*		5	1983	1991	
663	*Diurnea fagella*		1	2007	2007	
770	*Carpatolechia proximella*		3	1986	1988	
773	*Pseudotelphusa paripunctella*		2	1986	1989	

780	*Bryotropha similis*		1	1991	1991	
783	*Bryotropha boreella*		1	1991	1991	Nb
784	*Bryotropha galbanella*		5	1986	1991	Nb
794	*Prolita sexpunctella*		1	1988	1988	Nb
797	*Neofaculta ericetella*		7	1986	2005	
954	*Eupoecilia angustana*		4	1986	1991	
968	*Cochylis nana*		1	1986	1986	
970	*Pandemis cerasana*	Barred Fruit-tree Tortrix	3	1986	1988	
972	*Pandemis heparana*	Dark Fruit-tree Tortrix	2	1986	1986	
986	*Syndemis musculana*		1	1988	1988	
988	*Aphelia viburnana*	Bilberry Tortrix	2	1986	1986	
989	*Aphelia paleana*	Timothy Tortrix	1	2005	2005	
1007	*Capua vulgana*		1	1988	1988	
1008	*Philedone gerningana*		2	1991	2005	
1015	*Eulia ministrana*		2	1986	1988	
1021	*Cnephasia interjectana*		1	1986	1986	
1026	*Exapate congelatella*		1	1986	1986	
1055	*Acleris hyemana*		1	1986	1986	
1057	*Acleris rufana*		1	1986	1986	
1073	*Olethreutes schulziana*		4	1991	2005	
1076	*Celypha lacunana*		2	1986	1986	
1087	*Orthotaenia undulana*		4	1983	1988	
1092	*Apotomis turbidana*		3	1986	1988	
1093	*Apotomis betuletana*		2	1986	1986	
1095	*Apotomis sororculana*		2	1986	1986	
1117	*Ancylis unguicella*		2	1988	2006	
1126	*Ancylis badiana*		1	2005	2005	
1128	*Ancylis myrtillana*		1	1991	1991	
1133	*Epinotia bilunana*		1	1988	1988	
1134	*Epinotia ramella*		4	1986	2003	
1137	*Epinotia tetraquetrana*		4	1983	1988	
1151	*Epinotia stroemiana*		2	1986	1986	
1151	*Epinotia trigonella*		2	1989	2006	
1155	*Epinotia brunnichana*		2	1986	1991	
1156	*Epinotia solandriana*		3	1986	1989	
1159	*Rhopobota naevana*	Holly Tortrix	2	1986	1986	
1184	*Epiblema scutulana*		1	2006	2006	
1201	*Eucosma cana*		1	1986	1986	
1294	*Crambus pascuella*		3	1986	2005	Common
1301	*Crambus lathoniellus*		4	1986	2006	Common
1304	*Agriphila straminella*		2	1986	1986	Common
1305	*Agriphila tristella*		2	1986	2005	Common
1314	*Catoptria margaritella*	Pearl-band Grass Veneer	7	1986	2005	Local
1334	*Scoparia ambigualis*		8	1986	2006	Common
1338	*Dipleurina lacustrata*		1	1986	1986	Common
1340	*Eudonia truncicolella*		2	1986	1986	Common
1345	*Elophila nymphaeata*	Brown China-mark	5	2004	2010	Common
1350	*Nymphula stagnata*	Beautiful China-mark	3	2006	2010	Common
1356	*Evergestis forficalis*	Garden Pebble	1	2004	2004	Common
1388	*Udea lutealis*		3	1989	2007	Common
1395	*Udea ferrugalis*	Rusty-dot Pearl	2	1989	1989	Migrant
1405	*Pleuroptya ruralis*	Mother of Pearl	4	2004	2005	Common
1632	*Trichiura crataegi*	Pale Eggar	1	1991	1991	Common
1637	*Lasiocampa quercus f. callunae*	Northern Eggar	7	1973	2010	Common
1638	*Macrothylacia rubi*	Fox Moth	16	1973	2010	Common
1640	*Euthrix potatoria*	Drinker	21	1973	2010	Common
1643	*Saturnia pavonia*	Emperor Moth	7	1973	2010	Common

1645	*Falcaria lacertinaria*	Scalloped Hook-tip	12	1973	2010	Common
1648	*Drepana falcataria*	Pebble Hook-tip	8	1973	2010	Common
1657	*Ochropacha duplaris*	Common Lutestring	7	1986	2010	Common
1659	*Achlya flavicornis*	Yellow Horned	4	1973	2010	Common
1661	*Archiearis parthenias*	Orange Underwing	2	1974	2007	Local
1666	*Geometra papilionaria*	Large Emerald	5	1988	2010	Common
1677	*Cyclophora albipunctata*	Birch Mocha	2	1973	2010	Local
1694	*Scopula ternata*	Smoky Wave	7	1973	2010	Local
1702	*Idaea biselata*	Small Fan-footed Wave	3	1986	2006	Common
1713	*Idaea aversata*	Riband Wave	6	1986	2007	Common
1715	*Idaea straminata*	Plain Wave	6	1986	2010	Local
1722	*Xanthorhoe designata*	Flame Carpet	2	2010	2010	Common
1723	*Xanthorhoe decoloraria*	Red Carpet	2	2004	2004	Common
1724	*Xanthorhoe spadicearia*	Red Twin-spot Carpet	1	2005	2005	Common
1725	*Xanthorhoe ferrugata*	Dark-barred Twin-spot Carpet	1	2010	2010	Common
1727	*Xanthorhoe montanata*	Silver-ground Carpet	8	1973	2010	Common
1737	*Epirrhoe tristata*	Small Argent & Sable	7	1973	1998	Common
1738	*Epirrhoe alternata*	Common Carpet	11	1973	2010	Common
1752	*Cosmorhoe ocellata*	Purple Bar	2	1973	2007	Common
1755	*Eulithis testata*	Chevron	15	1973	2010	Common
1756	*Eulithis populata*	Northern Spinach	2	1973	2010	Common
1758	*Eulithis pyraliata*	Barred Straw	2	2004	2006	Common
1760	*Chloroclysta siterata*	Red-green Carpet	1	2010	2010	Common
1762	*Chloroclysta citrata*	Dark Marbled Carpet	3	1973	2004	Common
1764	*Chloroclysta truncata*	Common Marbled Carpet	4	1973	2010	Common
1768	*Thera obeliscata*	Grey Pine Carpet	7	1973	2010	Common
1769	*Thera britannica*	Spruce Carpet	4	2006	2010	Common
1773	*Electrophaes corylata*	Broken-barred Carpet	4	1973	2010	Common
1775	*Colostygia multistrigaria*	Mottled Grey	2	1973	2005	Common
1776	*Colostygia pectinataria*	Green Carpet	6	1973	2010	Common
1777	*Hydriomena furcata*	July Highflyer	5	1973	2005	Common
1787	*Rheumaptera hastata*	Argent & Sable	18	1973	2010	Nb
1803	*Perizoma alchemillata*	Small Rivulet	2	1981	2004	Common
1809	*Perizoma didymata*	Twin-spot Carpet	4	1973	2005	Common
1831	*Eupithecia absinthiata f. goossensiata*	Ling Pug	3	1986	1991	Local
1837	*Eupithecia subfuscata*	Grey Pug	2	1986	2005	Common
1840	*Eupithecia subumbrata*	Shaded Pug	1	2010	2010	Local
1846	*Eupithecia nanata*	Narrow-winged Pug	9	1973	2007	Common
1857	*Eupithecia tantillaria*	Dwarf Pug	1	2010	2010	Common
1862	*Gymnoscelis rufifasciata*	Double-striped Pug	3	1973	2010	Common
1866	*Carsia sororiata*	Manchester Treble-bar	22	1973	2010	Nb
1887	*Lomaspilis marginata*	Clouded Border	5	1973	2010	Common
1902	*Petrophora chlorosata*	Brown Silver-line	6	1974	2005	Common
1904	*Plagodis dolabraria*	Scorched Wing	1	2010	2010	Local
1906	*Opisthograptis luteolata*	Brimstone Moth	6	1973	2010	Common
1913	*Ennomos alniaria*	Canary-shouldered Thorn	13	1973	2007	Common
1917	*Selenia dentaria*	Early Thorn	2	1973	2004	Common
1918	*Selenia lunularia*	Lunar Thorn	2	2005	2010	Local
1919	*Selenia tetralunaria*	Purple Thorn	1	2004	2004	Common
1920	*Odontopera bidentata*	Scalloped Hazel	5	1973	2007	Common
1921	*Crocallis elinguaria*	Scalloped Oak	2	2004	2007	Common
1926	*Phigalia pilosaria*	Pale Brindled Beauty	2	1973	2005	Common
1929	*Lycia lapponaria*	Rannoch Brindled Beauty	22	1973	2010	Na
1931	*Biston betularia*	Peppered Moth	8	1973	2010	Common
1935	*Erannis defoliaria*	Mottled Umber	2	1973	1988	Common
1941	*Alcis repandata*	Mottled Beauty	1	1973	1973	Common
1947	*Ectropis bistortata*	Engrailed	3	2009	2010	Common

1951	*Aethalura punctulata*	Grey Birch	2	1991	2010	Common
1952	*Ematurga atomaria*	Common Heath	13	1973	2010	Common
1954	*Bupalus piniaria*	Bordered White	8	1973	2010	Common
1955	*Cabera pusaria*	Common White Wave	13	1973	2010	Common
1956	*Cabera exanthemata*	Common Wave	1	1973	1973	Common
1961	*Campaea margaritata*	Light Emerald	5	1986	2007	Common
1962	*Hylaea fasciaria*	Barred Red	3	1986	2010	Common
1969	*Dyscia fagaria*	Grey Scalloped Bar	6	1973	2007	Local
1970	*Perconia strigillaria*	Grass Wave	23	1973	2010	Local
1981	*Laothoe populi*	Poplar Hawk-moth	4	1973	2005	Common
1991	*Deilephila elpenor*	Elephant Hawk-moth	6	2004	2010	Common
1992	*Deilephila porcellus*	Small Elephant Hawk-moth	4	2004	2010	Local
1994	*Phalera bucephala*	Buff-tip	7	1973	2010	Common
1995	*Cerura vinula*	Puss Moth	2	1973	2007	Common
1997	*Furcula furcula*	Sallow Kitten	1	1973	1973	Common
2000	*Notodonta dromedarius*	Iron Prominent	18	1973	2010	Common
2003	*Notodonta ziczac*	Pebble Prominent	2	2005	2010	Common
2006	*Pheosia gnoma*	Lesser Swallow Prominent	19	1973	2010	Common
2008	*Ptilodon capucina*	Coxcomb Prominent	8	1973	2010	Common
2011	*Pterostoma palpina*	Pale Prominent	4	2004	2010	Common
2026	*Orgyia antiqua*	Vapourer	4	1973	2005	Common
2027	*Dicallomera fascelina*	Dark Tussock	10	1973	2005	Local
2035	*Thumatha senex*	Round-winged Muslin	2	1970	1991	Local
2039	*Atolmis rubricollis*	Red-neeked Footman	3	2005	2006	Local
2040	*Cybosia mesomella*	Four-dotted Footman	15	1973	2010	Local
2056	*Parasemia plantaginis*	Wood Tiger	5	1973	2007	Local
2057	*Arctia caja*	Garden Tiger	3	2004	2010	Common
2059	*Diacrisia sannio*	Clouded Buff	10	1974	2010	Local
2060	*Spilosoma lubricipeda*	White Ermine	10	1973	2010	Common
2064	*Phragmatobia fuliginosa*	Ruby Tiger	5	1973	2010	Common
2089	*Agrotis exclamationis*	Heart and Dart	1	2004	2004	Common
2098	*Axylia putris*	Flame	1	2004	2004	Common
2102	*Ochropleura plecta*	Flame Shoulder	6	1973	2010	Common
2107	*Noctua pronuba*	Large Yellow Underwing	22	1974	2010	Common
2109	*Noctua comes*	Lesser Yellow Underwing	3	2005	2007	Common
2110	*Noctua fimbriata*	Broad-bordered Yellow Underwing	1	2007	2007	Common
2111	*Noctua janthe*	Lesser Broad-bordered Yellow Underwing	3	2005	2007	Common
2117	*Eugnorisma glareosa*	Autumnal Rustic	6	2004	2007	Common
2118	*Lycophotia porphyrea*	True Lover's Knot	19	1973	2010	Common
2120	*Diarsia mendica*	Ingrailed Clay	15	1973	2010	Common
2123	*Diarsia rubi*	Small Square-spot	3	2010	2010	Common
2128	*Xestia triangulum*	Double Square-spot	1	2004	2004	Common
2130	*Xestia baja*	Dotted Clay	9	2005	2010	Common
2132	*Xestia castanea*	Neglected Rustic	6	2005	2007	Local
2133	*Xestia sexstrigata*	Six-striped Rustic	2	2005	2006	Common
2134	*Xestia xanthographa*	Square-spot Rustic	5	2004	2007	Common
2135	*Xestia agathina*	Heath Rustic	5	2005	2007	Local
2137	*Eurois occulta*	Great Brocade	3	2006	2010	Na
2142	*Anarta myrtilli*	Beautiful Yellow Underwing	11	1973	2005	Common
2147	*Hada nana*	Shears	1	2004	2004	Common
2149	*Polia trimaculosa*	Silvery Arches	2	2004	2010	Nb
2156	*Lacanobia contigua*	Beautiful Brocade	3	2004	2010	Local
2158	*Lacanobia thalassina*	Pale-shouldered Brocade	6	2004	2010	Common
2160	*Lacanobia oleracea*	Bright-line Brown-eye	4	2006	2007	Common
2162	*Papestra biren*	Glaucous Shears	4	2004	2010	Local
2163	*Melanchra pisi*	Broom Moth	10	1973	2010	Common
2176	*Cerapteryx graminis*	Antler Moth	11	1973	2010	Common

2179	*Panolis flammea*	Pine Beauty	2	2005	2010	Common
2186	*Orthosia gracilis*	Powdered Quaker	1	2010	2010	Common
2187	*Orthosia cerasi*	Common Quaker	3	2005	2010	Common
2188	*Orthosia incerta*	Clouded Drab	3	2005	2010	Common
2190	*Orthosia gothica*	Hebrew Character	5	2004	2010	Common
2198	*Mythimna impura*	Smoky Wainscot	13	1973	2010	Common
2199	*Mythimna pallens*	Common Wainscot	2	1973	2006	Common
2225	*Brachylomia viminalis*	Minor Shoulder-knot	1	2005	2005	Common
2232	*Aporophyla nigra*	Black Rustic	1	2005	2005	Common
2233	*Lithomoia solidaginis*	Golden-rod Brindle	4	1973	2007	Local
2241	*Xylena vetusta*	Red Sword-grass	2	1973	2010	Local
2250	*Blepharita adusta*	Dark Brocade	3	2004	2007	Common
2258	*Conistra vaccinii*	Chestnut	1	2005	2005	Common
2266	*Agrochola litura*	Brown-spot Pinion	2	2006	2006	Common
2268	*Parastichtis suspecta*	Suspected	2	2005	2006	Local
2273	*Xanthia togata*	Pink-barred Sallow	3	2005	2007	Common
2274	*Xanthia icteritia*	Sallow	4	2004	2007	Common
2280	*Acronicta leporina*	Miller	6	1986	2010	Common
2286	*Acronicta menyanthidis*	Light Knot Grass	12	1973	2010	Local
2300	*Mormo maura*	Old Lady	1	2005	2005	Local
2302	*Rusina ferruginea*	Brown Rustic	6	2004	2010	Common
2305	*Euplexia lucipara*	Small Angle Shades	1	2005	2005	Common
2306	*Phlogophora meticulosa*	Angle Shades	2	2004	2006	Common
2321	*Apamea monoglypha*	Dark Arches	16	2004	2010	Common
2326	*Apamea crenata*	Clouded-bordered Brindle	12	2004	2010	Common
2330	*Apamea remissa*	Dusky Brocade	1	2007	2007	Common
2334	*Apamea sordens*	Rustic Shoulder-knot	1	2004	2004	Common
2340	*Oligia fasciuncula*	Middle-barred Minor	6	1973	2010	Common
2343x	*Mesapamea secalis agg.*	Common Rustic agg.	13	1973	2010	
2345	*Photedes minima*	Small Dotted Buff	1	2004	2004	Common
2350	*Chortodes pygmina*	Small Wainscot	9	1973	2007	Common
2357	*Amphipoea lucens*	Large Ear	4	2005	2010	Local
2360x	*Amphipoea oculea agg.*	Ear Moth agg.	15	1973	2010	
2361	*Hydraecia micacea*	Rosy Rustic	5	1973	2006	Common
2364	*Gortyna flavago*	Frosted Orange	2	2005	2007	Common
2367	*Celaena haworthii*	Haworth's Minor	6	1973	2007	Local
2368	*Celaena leucostigma*	Crescent	3	2005	2010	Local
2369	*Nonagria typhae*	Bulrush Wainscot	1	2006	2006	Common
2422	*Pseudoips prasinana*	Green Silver-lines	1	2004	2004	Common
2425	*Colocasia coryli*	Nut-tree Tussock	8	1986	2010	Common
2434	*Diachrysia chrysitis*	Burnished Brass	1	2005	2005	Common
2439	*Plusia festucae*	Gold Spot	3	2004	2006	Common
2440	*Plusia putnami*	Lempke's Gold Spot	4	1998	2007	Local
2441	*Autographa gamma*	Silver Y	2	1989	2006	Migrant
2443	*Autographa jota*	Plain Golden Y	2	2005	2006	Common
2444	*Autographa bractea*	Gold Spangle	2	2005	2007	Common
2447	*Syngrapha interrogationis*	Scarce Silver Y	1	2006	2006	Local
2450	*Abrostola tripartita*	Spectacle	1	2004	2004	Common
2474	*Rivula sericealis*	Straw Dot	7	1986	2010	Common
2477	*Hypena proboscidalis*	Snout	5	1973	2005	Common
2484	*Schrankia costaestrigalis*	Pinion-streaked Snout	1	2010	2010	Local Nb
2485	*Hypenodes humidalis*	Marsh Oblique-barred	4	1986	2010	

Table 1. Moth species recorded on Flanders Moss.

English Name	Scientific Name	UK-wide percentage change over 35 years	IUCN Category
Autumnal Rustic	*Eugnorisma glareosa*	-92	Endangered
Garden Tiger	*Arctia caja*	-89	Vulnerable
Haworth's Minor	*Celaena haworthii*	-89	Vulnerable
Pale Eggar	*Trichiura crataegi*	-86	Vulnerable
Small square-spot	*Diarsia rubi*	-85	Vulnerable
Heath Rustic	*Xestia agathina*	-84	Vulnerable
Sallow	*Xanthia iceritia*	-82	Vulnerable
Crescent	*Cymatophorima leucostigma*	-82	Vulnerable
Neglected Rustic	*Xestia castanea*	-82	Vulnerable
Dark Brocade	*Blepharita adusta*	-78	Vulnerable
White Ermine	*Spilosoma lubricipeda*	-77	Vulnerable
Dusky Brocade	*Apamea remissa*	-76	Vulnerable

Table 2. Moths found on Flanders Moss that declined in their UK-wide abundance by more than 70% between 1968 and 2002.

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Diversity of wild plants in a low-maintenance Scottish suburban garden. Then and now – 1986 and 2011

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In 1986, prior to the publication of the Wild Plants of Glasgow (Dickson, 1991), a survey was undertaken of the native (or naturalised) higher plant diversity of a large suburban garden in the south side of Glasgow. The garden harboured over sixty wild plant species, including a few unusual species for the area. A follow up survey was undertaken 25 years later in 2011, to assess how the natural plant eommunity had changed over the years. Plants were identified with the aid of Keble Martin (1969), Garrard & Streeter (1983), and Phillips (1980). Nomenclature has been updated to match Dickson *et al.* (2000).

The garden located on Newark Drive in Pollokshields (NS 57225 63075) is moderately large with a footprint of around 1200m^2. The layout comprises, to the front, a gravel driveway and a lawn with bordering beds with a few shrubs and mature trees (lime, norway maple, sycamore, horse chestnut, holly, common whitebeam, laburnum and wych elm) (see Fig.1). The side gardens have an old concrete drive, grass areas, gravel paths and small trees (ash, rowan, silver bireh, locust tree) (see Fig.2) and the rear garden has more extensive grass areas, a concrete garage forecourt, some overgrown beds, a former vegetable garden and a few mature trees (lime, alder, wild cherry and apple) (see Fig.3). The garden was intensively cultivated in the 1960s with many formal beds of flowers, neat lawns, pollarded trees, vegetable patches as well as a large greenhouse and numerous exterior cold frames. From the early 1970s the eultivation regime reduced rapidly to a low maintenance level. Tree pruning ceased, the greenhouse was dismantled, and many beds and vegetable patches were converted to grass or simply became overgrown with weeds. Lawn mowing continued but bed weeding was minimal, limited to removal of large saplings with only shrubs and some hardy perennial garden flowers persisting. The front driveway was maintained with occasional weeding or application of weed killer but the concrete drive and forecourt and other paths gradually beeame overgrown with grass and weeds.

The initial survey in 1986 recorded 51 species of native (or naturalised) flowering plants, five fern species and one horsetail (Table 1). Grasses added another, often hidden, component of higher plant diversity. Mowing and strimming often limited grass identification but during the early 1980s ten speeies of grass (and one rush) were identified within the garden (Table 2). The flowering plants ineluded a variety of annual weeds (*eg.* thale cress, cleavers, groundsel) and several pernieious perennial "weeds" - the bane of gardeners - rosebay willowherb, ground-elder, field horsetail, large bindweed, japanese knotweed. The grassy areas had their own distinctive flora including creeping buttercup, daisy, self-heal, and thyme-leaved speedwell. A few shade tolerant woodland species sueh as lesser celandine, broad-leaved helleborine and bluebell were already present under mature trees.

Some species were elearly garden escapes (*ie.* welsh poppy, feverfew) and others, although indigenous to Scotland, are known to have been intentional introduetions into the garden in the 1970s: shining crane's-bill from Lennoxtown, barren strawberry from Roebank Reservoir, water avens from Dalry (Ayrshire), great mullein from Dumfries, eaper spurge from the derelict greenhouse of a neighbouring garden, and bluebell from Pollok Park. Others may have previously arrived with soil from greenhouse plants. This is probably the case (indirectly) for the caper spurge mentioned above and for the greater burnet-saxifrage which appeared in the early 1980s in the area of the dismantled greenhouse. The eaper spurge was introduced in 1974 and persisted by self seeding around the garden for around 12 years. It is rare in the Glasgow area, being recorded from only four tetrads (Dickson *et al.* 2000). The greater burnet-saxifrage appeared as a seedling in 1981 and comprised four large plants by 1986. It is very rare in Scotland and this was the first record for the Glasgow area (Dickson *et al.* 2000).

Aecidental introduetion of some plants with commercial grass seed mix during eonversion of some former flower beds into lawns was also a known arrival route into the garden for at least three unusual species - black nightshade (*Solanum nigrum*) in 1978), small-flowered catchfly (*Silene gallica*) in 1980, and field madder (*Sherardia arvensis*) in 1981– but none of these persisted into the following years.

Four species of fern were present in 1986. Male-fern and lady-fern were scattered throughout the garden. There were three broad buckler-fern plants – introduced from Pollok Park and on the garden walls a single hard shield-fern and a single maidenhair spleenwort.

The follow-up survey in 2011 revealed that the number of wild flower species established in the garden had increased to 60 and the number of fern species remained the same at five. Some flower species (*e.g.* barren strawberry, germander speedwell, self-heal, bluebell) have spread and increased in abundance, others have decreased (*e.g.* red campion, american willowherb, daisy, feverfew). Altogether nine flower species and two ferns have disappeared and 18 new flower species and two new ferns have arrived. Mowing and strimming prevented a proper review of the grass species in 2011.

In addition to the flowering plants and ferns found in 2011, a large number of tree (or shrub) seedlings or saplings were noted sprouting on lawns and old border beds (Table 3). In spring 2011 nearly thirty lime seedlings (cotyledon stage) were observed on the lawn areas. Regeneration of lime is relatively unusual in Scotland (see Gray, Grist, & Hansen 1999).

Among the absentees in 2011 were several annual weeds (shepherd's purse, groundsel, and common orache) possibly edged out by overgrowth of grasses and thickets of bramble in some areas. Newly arrived weeds included ivy-leaved speedwell, knotgrass, smooth sow-thistle, curled dock, common nettle, great willowherb and bramble. Another new weed, blinks, formed extensive patches on the gravel driveway. The introduced water avens, greater burnet-saxifrage, great mullein, and caper spurge have all died out along with the single bittersweet. The arrival of the two-spined acaena is of interest (Fig.4). Although this alien species is still rare as a naturalised plant in Glasgow it may be spreading.

In the grassy areas greater plantain seems to have disappeared while a few ribwort plantain have arrived. The alien fox-and-cubs ("orange hawkweed") has invaded the front lawn and, with a low growth habit resistant to mowing, has become exceedingly abundant and a garden variety of lady's mantle has turned up on a grassed over driveway. Several cuckooflower have also appeared in recent years in the grassy areas although these are more susceptible to mowing and flowering stalks persist only on untrimmed grassy borders.

The continued growth of mature (and maturing) trees has encouraged the development of a woodland flora under their shade. Lesser celandine has expanded from a few patches to broad carpets. The dozen or so native bluebell introduced in the eighties have now formed into two natural "bluebell glades" with over 150 plants. However non-native spanish bluebell has also spread from neighbouring gardens and it appears that they may already be hybridising with the native bluebell (see Dickson, 1991, Dickson *et al.* 2000). Four new shade-tolerant woodland species have colonised the garden; wood avens and wild strawberry, both of which are already widespread, a patch of enchanter's nightshade, and a single flowering plant of ramsons.

Among the ferns the broad buckler-fern and hard shield-fern have gone but the shade loving hart's-tongue has arrived. The single maidenhair spleenwort on the garden wall has expanded to over 100 plants and a few plants of wall-rue have established on the same wall, spread from a new colony of about 50 plants on an adjacent neighbour's wall.

Gardens are often overlooked when it comes to surveys of natural flora. It is evident from the small number examined in preparation for the Wild Plants of Glasgow (Dickson, 1991) that suburban gardens, especially if a little unkempt, can host a surprising diversity of natural flora. In well cultivated gardens the natural flora will be dominated by plants of arable land (*i.e.* weeds of flower beds) or grazed pasture (*i.e.* weeds of lawns) but where the maintenance is less strict and where trees are allowed to mature then woodland species may become established.

Accidental introduction from horticulture via grass seeding, flower seed packs or potted plants from garden centres may result in the presence of some unexpected native species. At Newark Drive accidental (or intentional) introduction has been the source of several such arrivals. Mud on tyre treads or wheel arches may possibly explain the spread of some driveway weeds such as blinks and knotgrass. Most of the other plant arrivals probably derive from windblown seeds (or spores). This is undoubtedly the case for most weed species, for broad-leaved helleborine orchids, and for fern species. Others such as bramble and wild strawberries may arrive as seeds within bird droppings. Wood avens and enchanter's nightshade with barbed seeds may perhaps arrive attached to bird's feathers or on the fur of foxes or cats. The spread of the alien two-spined acaena is likely to be similar.

Colonisation by tree seedlings is mainly by wind blown seeds from near and far. Two goat willow saplings noted in 2011 were growing in the house roof gutter, 8m above ground, on a bed of pigeon droppings! Although only about 30 cm tall they were already reproducing with catkins. Other trees which produce berries (rowan, whitebeam, hawthorn, wild cherry, holly and elder) may be spread via bird droppings. There is evidence in the form of gnawed cherry stones secreted in holes that mice may also help distribute the wild cherry, while grey squirrels (rare in this area in the 1980s but now common) are a possible candidate for distribution of horse chestnuts.

Species		1986 status	2011 status
creeping buttercup	*Ranunculus repens*	common	common
meadow buttercup	*Ranunculus acris*	one plant	one plant
lesser celandine	*Ranunculus ficaria*	several patches	abundant
welsh poppy	*Meconopsis cambrica*	common	common
wavy bitter cress	*Cardamine flexuosa*	common	common
cuckooflower	*Cardamine pratensis*	**absent**	five plants
shepherd's-purse	*Capsella bursa-pastoris*	a few on paths	**absent**
thale cress	*Arabidopsis thaliana*	common	common
red campion	*Silene dioica*	common	one plant
common mouse-ear	*Cerastium fontanum*	one patch on lawn	several on lawn
blinks	*Montia fontana*	**absent**	abundant
procumbent pearlwort	*Sagina procumbens*	common on paths	a few on paths
herb-robert	*Geranium robertianum*	common	common
shining crane's-bill	*Geranium lucidum*	common	common
white clover	*Trifolium repens*	common on lawn	common on lawn
bush vetch	*Vicia sepium*	one large patch	four patches
lady's mantle	*Alchemilla mollis*	**absent**	three plants
two-spined acaena	*Acaena ovalifolia*	**absent**	one plant
bramble	*Rubus fruticosus s.l.*	**absent**	abundant
barren strawberry	*Potentilla sterilis*	five plants	common
wild strawberry	*Fragraria vesca*	**absent**	common
waters avens	*Geum rivale*	15 plants	**absent**
wood avens	*Geum urbanum*	absent	common
rosebay willowherb	*Chamerion angustifolium*	several stands	two stands
broad-leaved willowherb	*Epilobium montanum*	common	common
american willowherb	*Epilobium ciliatum*	30 plants	one plant
great willowherb	*Epilobium hirsutum*	**absent**	two stands
ground-elder	*Aegopodium podagraria*	abundant	abundant
greater burnet-saxifrage	*Pimpinella major*	four plants	**absent**
pignut	*Conopodium majus*	one on grass	one on grass
enchanter's nightshade	*Circaea lutetiana*	**absent**	twenty plants
common ivy	*Hedera helix*	several on walls	common
cleavers	*Galium aparine*	common	common
daisy	*Bellis perennis*	common on lawns	a few on lawns
feverfew	*Tanacetum parthenium*	common	two plants
groundsel	*Senecio vulgaris*	common	**absent**
common ragwort	*Senecio jacobaea*	several	common
creeping thistle	*Cirsium arvense*	common	four plants
spear thistle	*Cirsium vulgare*	common	two plants
cat's-ear	*Hypochaeris radicata*	several on lawn	common on lawn
common hawkweed	*Hieraceum vulgatum*	a few on grass	three plants
fox-and-cubs	*Pilosella aurantiaca*	absent	abundant on lawn
dandelion	*Taraxacum sp.*	common	common
smooth sow-thistle	*Sonchus oleraceus*	**absent**	two plants
nipplewort	*Lapsana communis*	common	common
field forget-me-not	*Myosotis arvensis*	common on paths	six plants
large bindweed	*Calystegia silvatica*	common	common
bittersweet	*Solanum dulcamara*	one plant	**absent**
great mullein	*Verbascum thapsus*	one plant	**absent**
ivy-leaved toadflax	*Cymbalaria muralis*	common on walls	common on walls
foxglove	*Digitalis purpurea*	common	five plants
ivy-leaved speedwell	*Veronica hederifolia*	**absent**	three on drive
thyme-leaved speedwell	*Veronica serpyllifolia*	common on grass	common on grass
germander speedwell	*Veronica chamaedrys*	a few on grass border	abundant on grass border
selfheal	*Prunella vulgaris*	one patch	common
greater plantain	*Plantago major*	a few on grass	**absent**
ribwort plantain	*Plantago lanceolata*	**absent**	three on grass

common orache	*Atriplex patula*	a few on paths	**absent**
knotgrass	*Polygonum aviculare*	**absent**	ten plants on drive
japanese knotweed	*Fallopia japonica*	common	common
common sorrel	*Rumex acetosa*	common on grass	a few on grass
broad-leaved dock	*Rumex obtusifolius*	common	common
curled dock	*Rumex crispus*	**absent**	one plant
caper spurge	*Euphorbia lathyris*	one plant	**absent**
common nettle	*Urtica dioica*	**absent**	one small patch
broad-leaved helleborine	*Epipactis helleborine*	four under trees	nine under trees
ramsons	*Allium ursinum*	**absent**	one under trees
bluebell	*Hyacinthoides non-scriptus*	twelve under trees	common
spanish bluebell	*Hyacinthoides hispanica*	**absent**	several clumps
male-fern	*Dryopteris filix-mas*	several	several
broad buckler-fern	*Dryopteris dilitata*	three plants	**absent**
lady-fern	*Athyrium filix-femina*	several	several
hard shield-fern	*Polystichum aculeatum*	one on wall	**absent**
hart's-tongue	*Asplenium scolopendrium*	**absent**	several
wall-rue	*Asplenium ruta-muraria*	**absent**	five on wall
maidenhair spleenwort	*Asplenium trichomanes*	one on wall	abundant on wall
field horsetail	*Equisetum arvense*	common	common

Table 1. Wild (and naturalised) flowers and ferns 1986 and 2011.

It is clear from the relative abundances of the tree seedlings and saplings that, left to itself, this suburban garden would quickly revert to deciduous woodland dominated by sycamore and norway maple, neither of which is native to Scotland (Dickson *et al.* 2000), with an under-storey of shade-tolerant woodland plants.

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Fig.1. Newark Drive – Front garden with border of mature trees.

Fig.2. Newark Drive - Grassed over concrete driveway.

Fig.3. Newark Drive - Rear garden.

Fig.4. Newark Drive - Two-spined acaena.

Species	
red fescue	*Festuca rubra*
perennial rye-grass	*Lolium perenne*
crested dog's-tail	*Cynosurus cristatus*
annual meadow-grass	*Poa annua*
cock's-foot	*Dactylis glomerata*
yorkshire-fog	*Holcus lanatus*
sweet vernal-grass	*Anthoxanthum oderatum*
reed canary-grass	*Phalaris arundinacea*
timothy	*Phleum pratense*
common couch	*Elytrigia repens*
field wood-rush	*Luzula campestris*

Table 2. Grass and rush species in the 1980s.

Species		No. of seedlings/saplings
wych elm	*Ulmus glabra*	1
silver birch	*Betula pendula*	3
alder	*Alnus glutinosa*	6
lime	*Tilia x europaea*	27
goat willow	*Salix caprea*	3
wild cherry	*Prunus avium*	10
cherry laural	*Prunus laurocerasus*	6
rowan	*Sorbus aucuparia*	5
common whitebeam	*Sorbus aria*	1
hawthorn	*Crataegus monogyna*	3
broom	*Cytisus scoparius*	1
holly	*Ilex aquifolium*	4
horse chestnut	*Aesculus hippocastanum*	10
norway maple	*Acer platanoides*	100s
sycamore	*Acer pseudoplatanus*	100s
ash	*Fraxinus excelsior*	3
elder	*Sambucus nigra*	2

Table 3. Tree (and shrub) seedlings and saplings in 2011.

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The Blodwen Lloyd Binns Bequest: its contribution to the development of Glasgow Natural History Society

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ABSTRACT
Professor Blodwen Lloyd Binns (BLB) left a substantial legacy to Glasgow Natural History Society on her death in 1991. In her will, the bequest was 'unconditional', but she made a number of suggestions on how the money could be used both in her will and in additional correspondence. In this paper, we describe how the Society has used the income generated by this generous bequest in the 20 years since BLB's death. The paper covers the management of the bequest, the income generated and expenditure on the Society's activities (nearly £214,000). The bequest has supported the Society's journal *The Glasgow Naturalist* and other publications, biological recording, overseas expeditions, a lecture series, a multitude of research projects and the Society's social activities (one of BLB's specific suggestions). It is no exaggeration to say that the bequest has had a transformative effect on the Society and that, with prudent management, this effect should continue into the future.

INTRODUCTION
Blodwen Lloyd Binns (BLB) died in her 90th year in August 1991, having been a member of Glasgow Natural History Society (initially in its earlier name of the Andersonian Naturalists of Glasgow: see Sutcliffe, 2001) since 1934. In her will, BLB left the Society a substantial legacy. Twenty years after her death seems an appropriate time to appraise the impact that her legacy has made on the Society's affairs.

As Macpherson (1992) recounted, BLB was a member of the Botany Department of Glasgow's Royal Technical College (later the University of Strathclyde) from 1926-62, then Professor of Botany at the new University of Malawi 1965-72. Her scientific work was wide-ranging, including fermentation and marine microbiology. To aid her botanical teaching, she produced a *Handbook of Botanical Diagrams* in 1935, with a second edition in 1949, reprinted seven times. It was the royalties on this book that made a substantial contribution to the legacy she was able to leave to the Society.

BLB's will was made in 1974 and states "this bequest… is unconditional but I express the hope that it may enable the Andersonian Naturalists a) to arrange for refreshments and thus encourage fraternising at their meetings b) to foster interest in their own under-valued history and achievements including their current activities in conjunction with and for the Botanical Society of the British Isles and the Vegetation Atlas" (quoted from BLB's will in the Society's archives).

Although BLB had stated that the bequest was "unconditional", she had also conveyed to the Society, in a series of eight communications to Peter Macpherson, a number of suggestions as to how the money might be used: these are listed in Table 1 (abstracted from a document in the Society's archives).

1. To complete her biography of Professor Scouler
2. To research a biography of Scott Elliot
3. To research a biography of Roger Hennedy
4. To produce a brochure of the early history of the Society
5. A publication on the Lost Flora of Glasgow
6. A publication on the Aliens and Adventives in Glasgow
7. A publication on the Lost Flora of Helensburgh
8. In collaboration with Strathclyde University, complete the following Herbarium Transcripts:
    a) Volume 1 Indigenous flowering plants
    b) Volume 2 Exotica
    c) Volume 3 Cryptograms
9. Consider helping Strathclyde University to catalogue the Herbarium
10. Improve the social aspect of the Society
11. Provide a home for the Society

Table 1. Blodwen Lloyd Binns's suggestions

After initially depositing the legacy in the Society's general fund, Council agreed to set up a sub-committee to administer the bequest. This first met on 4th March 1993 and comprised Prof Norman Grist (President), Jean Millar (General Secretary), Bob Gray (Treasurer), Dr Peter Macpherson (Scientific Adviser) and Bruce Lindsay (Financial Adviser). At that meeting, Norman Grist listed several categories for possible expenditure of the legacy and Peter Macpherson read the list of

"suggestions" from BLB's communications to him. Bruce Lindsay recommended appointment of a broker to advise on investments: the intention would be to maintain the capital, allowing for inflation, and spend the income generated: on the sum initially available - about £175,000 (a huge sum for a small organisation like GNHS), income expected could be around £10,500 per annum. At this first meeting, there were three applications for funding. It was agreed to investigate each further, and to produce a form for the use of all future applicants (summarised from the Minute of the first meeting of administrators of BLB's Bequest, in the Society's archives).

Downie (1998) reported on the first few years of the Bequest's use: by the end of 1997, £19,200 had been spent, 13% of this on the *Glasgow Naturalist* (enhancing its production standards, especially through the inclusion of colour), 15% on equipment, especially a computer and associated kit to bring the Society's work into the modern age, 2% on special lectures, 3% on social events, 5% on administration of the bequest and 62% on "projects". In terms of money spent, projects were 53% in the UK and 37% abroad, mostly undergraduate expeditions organised through the University of Glasgow's Exploration Society. Downie (1998) hoped that BLB would have approved, given her personal "history of adventurous botanising in far countries". Possibly less to BLB's taste, projects were 61% zoological, 38% botanical and 1% miscellaneous.
The aim of this paper is to analyse and report on the various contributions the BLB Bequest has made to GNHS in the 20 years since BLB's death.

1. MANAGEMENT OF THE BEQUEST AND CRITERIA FOR FUNDING

The rules for the management of the Bequest are laid down in the Society's Constitution. To comply with the requirements of the Office of the Scottish Charities Regulator (OSCR), the Constitution was amended in November 2010. The rules are as follows (summarised from the Society's Constitution, available on the Society's web-site):

The Bequest is administered by an Executive comprising the Society's President, General Secretary and Treasurer together with scientific and financial advisers (number not specified) appointed at the Society's AGM. The aims of the Executive are to put into effect the wishes of Professor Lloyd Binns and to further the aims of the Society. The Bequest is managed in such a way as broadly to preserve its capital value, allowing for inflation, with awards made from the income accruing from investments.

It is worth noting that Dr Peter Macpherson has served as a scientific adviser to the Bequest since its inception, and that Bruce Lindsay served as financial adviser from the start of the Bequest until 2009-10.

The BLB Committee now meets three times a year (September, January and March) to coincide with GNHS Council meetings. At these meetings, the Committee receives an update on the Bequest's finances, considers any changes needed in the investment portfolio, makes decisions on grant applications, receives reports from work funded by the Bequest and discusses any modifications proposed to the way in which the Bequest's income could be used.

Over the years, a number of activities have become established as being funded by the Bequest without the need for specific application. These are:

- A contribution to the social life of the Society. This funds wine at events like the September Exhibition, the Christmas Dinner, the BLB lecture and the Summer Social. It also funds the costs of pre-talk dinners for speakers. A summary of these costs is shown in Table 2. The Committee has taken the view that these contributions fit with BLB's express wish to "arrange for refreshments.. and encourage fraternising at meetings".
- A contribution to the costs of publication of *The Glasgow Naturalist* (see Table 2 and section 4).
- Funding of the BLB Lecture series (see section 9).

The bulk of the Bequest's income is disbursed following applications for grants (see section 3). The Committee has made a number of modifications to the criteria for support over the years. Currently, these are (summarised from the Society's web-site: Grant Information page):

- We assist individuals and groups in carrying out projects of natural history interest.
- Where we have to decide between the merits of competing applications, preference is given to Society members over non-members, to local over distant projects, and to projects likely to generate future publication. We will not normally give grants towards salaries.
- Limited support for postgraduate students to report their results at national and international conferences.
- Support for overseas natural history projects: this is given for two categories of project a) overseas natural history expeditions, mainly involving under-graduate expeditions; b) overseas natural history research by individuals.

In all cases, upper financial limits are advertised (and modified by the Committee from time to time). In addition, since the start of the Bequest it has been agreed that no grant greater than £2000 will be made without the approval of the Society's Council.

2. THE BEQUEST'S FINANCES

Figure 1a shows the market value of the Bequest's investments since 1993. As can be seen, there was a sharp rise over the first few years when applications for funding were significantly less than income generated and surpluses were re-invested, peaking at almost £316,000 in 1999.

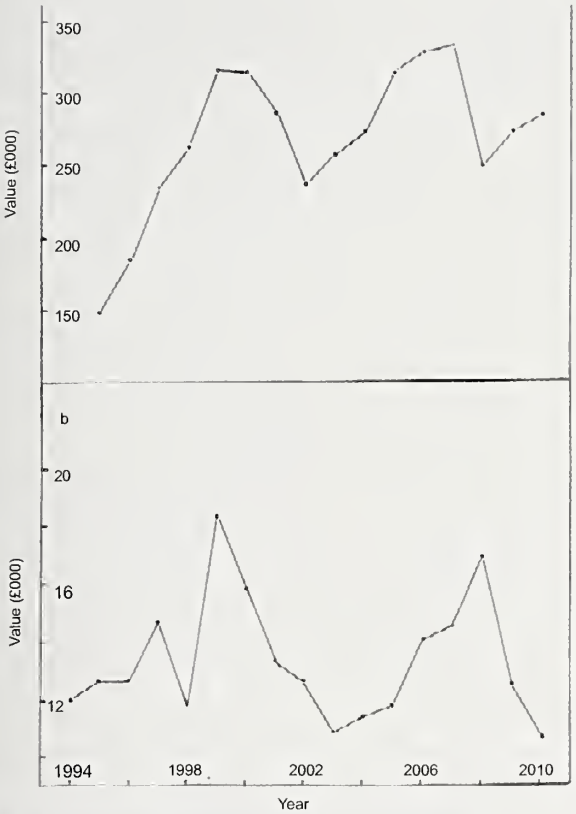

Fig. 1. Financial history of the BLB Bequest
a) Market value; b) Income

Subsequent changes in the market value of the Bequest's holdings have essentially followed the vagaries of the financial markets, especially the recent slump. Even with the recent fall in value in 2008, the Bequest is worth substantially more than at the start, even taking inflation into account. Figure 1b shows the annual income generated by the Bequest's investments. The overall policy of the Bequest Committee has been to hold a substantial proportion of the funds in 'safe' lowish interest investments, with a smaller proportion in carefully chosen stocks with potentially higher yields. Inevitably this has led to some variation in income, again generally following changes in the financial markets, but annual income has never fallen below £10,000, much in line with the original expectation and has generated a mean annual income of £13,327. The Bequest Committee was fortunate in having Bruce Lindsay's careful advice on investment policy over many years.

Table 2a shows the total income generated by the Bequest (1995-2010), total expenditure and a breakdown of the expenditure into its main categories. It is gratifying to note that overall administrative costs have been low (stockbroking, legal and general 5.5%). However, the 17-year average disguises some trends. Following a new arrangement with our stockbrokers, their fees rose substantially to 11.5% of income over the years 2007-10. The Committee regarded this as unacceptably high and a change was made during 2010.

a) Income, expenditure and main expenditure categories	
	Total (£) 1994-2010
Total Income	226,559
Total Expenditure	213,559
	£ and (%)
- Grants (%)	152,386 (71.4)
- Equipment (%)	8,223 (3.9)
- Publications (%)	18,408 (8.6)
- Social (%)	8,681 (4.1)
- Meetings (%)	12,502 (5.9)
- Stockbroking – Legal (%)	9,512 (4.5)
- Administration (%)	2036 (1.0)
b) Grants categories: percentage of total grant expenditure	
	(%)
Conferences, exhibitions	6.4
Habitat creation/memorial	2.3
Training courses	1.5
UG expeditions (59)	22.0
UK research	19.8
Overseas research	11.8
Collections/recording	8.6
Publications	24.3
Excursions	1.9
Donation (SCENE)	1.3

Table 2. Income generated by the BLB Bequest, and a breakdown of the main spending streams a) total income and main spending streams, b) breakdown of grant categories.

Contributions to social events and meetings average 10% of Bequest expenditure, well fulfilling BLB's request that her legacy should contribute to 'fraternisation'. A matter of concern to the Committee has been a recent steep rise in room charges imposed by our host, the University of Glasgow: without the benefit of the Bequest, the Society would certainly have had to move, in spite of the benefits of the Zoology Museum and our library being housed in the Graham Kerr Building.

Expenditure on equipment has taken up 3.8% of Bequest income. Most of this was in the early days, and was largely on computing equipment. Since 2005, the Society has had the benefit of an additional legacy (£8000, T.E. Kinsey): this is administered along with the BLB and is used wholly for the purchase of natural history equipment.

The second biggest expenditure category has been publications (8.6%). Initially, the Bequest simply made a contribution to colour printing in *The Glasgow Naturalist*. More recently, as production costs have risen and additional publications have been produced (see section 4), there has been substantial expenditure from time to time, but this is offset by income in some cases.

By far the biggest expenditure category has been grants (71.4%). An account of the variety of grants awarded is given in the next section.

3. ACTIVITIES SUPPORTED BY GRANTS

Table 2a gives a breakdown of the way in which the £152k on grants has been allocated. The four major items have been Publications, Undergraduate Expeditions, UK Research and Overseas Research. Over the years of the Bequest, there have been some changes in the procedures for recording expenditure, so there is a category of Publication in Table 2a as well as under grants. Most of the grant-aided publications have been for floras, especially the *Changing Flora of Glasgow* (2001), the largest single item funded by the Bequest at £8459 (as noted in section 8 and in Table 1, publications on the flora of Glasgow were among BLB's specific suggestions). The Bequest also funded a publication, jointly with Scottish Natural Heritage, on the flowers of Iona (Millar, 1993). See also section 8. The Undergraduate Expeditions (59) funded by the Bequest have all involved the University of Glasgow's Exploration Society and are discussed in section 7. Research projects both in the UK and overseas have been very varied: the Bequest has been valuable as a supplementary funder for postgraduate research projects where the consumables and travel budgets provided by the main grant have been inadequate – in this way, the Bequest has aided research on the diversity of sticklebacks in Scotland, the Gartcosh great crested newt translocation, overwintering of common frog tadpoles, local adaptations of common frogs in Scotland and wolf conservation in Ethiopia.

Collections and bio-recording (8.6% of grants) are described in section 6 as are the training courses aimed at improving identification and recording skills (1.5%). The Bequest has helped fund attendance at conferences and also the mounting of a number of exhibitions, most notably the *Animal Architecture Company*, the Hunterian Museum's contribution to Glasgow City of Design and Architecture (1999). A small proportion (2.3%) of grant funding has gone to habitat creation projects, such as wildlife gardens in schools and Froglife's *Living Waters* programme which is creating amphibian habitats around the country.

An important activity for the Society is the extensive series of excursions run each year, spring to autumn. These are largely self-funding, but a small proportion of the grant money (1.9%) has helped with these, especially with transport.

4. JOURNAL AND OTHER PUBLICATIONS (INCLUDING PRIZES FOR YOUNG AUTHORS)

The BLB Bequest gives financial support for the publication of *The Glasgow Naturalist. The Glasgow Naturalist* was first issued around 1908-9 and is a peer reviewed journal that publishes original studies in botany, zoology and geology, with a particular focus on studies from the West of Scotland. The journal is published on a 1-2 year basis and further supplements are produced to publish the proceedings of conferences. The Society is fortunate in receiving generous funding from the BLB Bequest to allow the continued publication of one of the best respected natural history journals in Scotland. The BLB currently contributes £1-£2k per edition for printing, materials and secretarial work.

The BLB prize is awarded for papers submitted for publication in *The Glasgow Naturalist*. The subject area is the natural history of Scotland. The intention of the prize is to encourage work by younger scientists - "younger" in the sense of new to scientific writing. Submitted work should therefore be amongst the first three papers the writer has submitted for publication. This prize was first awarded in 2008 and prizes have been made to:

Jill M. Williams, 2008. Flood meadow vegetation at Little Leny Meadows, Callander: comparison of two adjacent grazed and ungrazed meadows. *The Glasgow Naturalist* 25(1): 51-56.

Andrew Kyle. 2009. A comparison of grey squirrel (*Sciurus carolinensis*) densities between an urban park and semi-rural woodland in Glasgow. *The Glasgow Naturalist* 25(2): 23-26.

Lindsay J. Henderson. 2011. Pine martens, *Martes martes* as predators of nestling blue tits, *Cyanistes caeruleus*. *The Glasgow Naturalist* 25(3), 101-2.

The BLB Bequest has also supported publications written by members of the Society and made contribution to natural history publications of national interest. These include Knowler's (2010) checklist of the larger moths of Stirlingshire and surrounding areas; Dickson *et al.*'s (2000) book on the flora of Glasgow; Walker's (2003) book on useful herbs and Millar's (1993) book on the flowers of Iona; and Sutcliffe's (2010) book on interesting natural history sites of the Glasgow area.

5. CONFERENCES

Prior to the existence of the Bequest, conferences figured very rarely among the Society's activities. Since the Bequest, we have organised four (Table 3) at 2-4 year intervals. In all cases, the proceedings have been published, as sets of edited papers, in *The Glasgow Naturalist*, either as supplements or as part of a regular issue. In addition, the more recent three sets of proceedings have been published on-line. As shown in Table 3, conferences have usually been linked to an event, such as the Society's 150th anniversary, and have often involved a collaboration with other groups, such as the 2008 Machair conference, organised jointly with the RSPB and the Aculeate Conservation Group, to cap a three-year Esmée Fairbairn Foundation – funded project on the great yellow bumble-bee. Collaborations have helped to enlarge conference attendance, which has been excellent in all cases.

The Bequest's contributions have been a) to underwrite the costs of the conferences; b) to fund research

projects whose results have been presented at the meetings; and c) to support publications of the proceedings.

Month, Year	Conference Title	Duration (d)	Occasion	Publication
June, 2001	Alien species: friends or foes?	2	Society's 150^{th} Anniversary	GN 23 Supplement 2001
November, 2004	The natural history of Loch Lomond and the Trossachs	1	Recent opening of Loch Lomond & Trossachs National Park	GN 24 Part 3 2005
December 2008	Machair conservation: successes and challenges	1	Culmination of joint project	GN 25 Supplement 2009
October, 2010	Urban biodiversity: successes and challenges	2	International Year of Biodiversity	Pending

Table 3. GNHS Conferences

Although the conferences have been budgeted to break even, it has been very helpful to have the cushion of the Bequest in case of financial problems; and membership income alone could simply not have provided the funds for full-scale publication. In these ways, the Bequest has been a vital factor in allowing the organisation of high quality conferences which have considerably raised the profile of the Society amongst kindred organisations.

6. RECORDING

Historically the Society has always seen the recording of the wildlife of the Clyde Area as a priority, and has maintained organised lists in one form or another showing where various species were to be found (Weddle, 2001). Since the late 1990s this process has been considerably enhanced by a series of grants from BLB for projects aiming to collate or transcribe existing data for the Glasgow Museums Biological Record Centre database, and in recent years, financial support for taxonomic training courses.

As mentioned in section 8, the aspect closest to Blodwen's interests is the transcribing of data from the Strathclyde Herbarium sheets; so far, the British species - approximately 1484 bryophytes, 335 lichens and 2,168 flowering plant records - have been gleaned from a total of some 11,000 sheets. The remaining specimens are exotic and transcription awaits a suitably qualified volunteer. Continuing the botanical theme, we have also transcribed some 450 records from a 'Flora of Renfrewshire' compiled by, or under the auspices of, Morris Young the first Curator of Paisley Museum (Weddle, 2008).

There are also several hundred records in the manuscript accounts of field excursions by the Andersonian Naturalists' Society; a start has been made on transcribing these.

Another major project helped by BLB funding is the transcription of records of beetles from Anderson Fergusson's catalogue held by the Hunterian Museum some 3,050 records spanning the years 1860-1938, not all collected by Fergusson himself. This was added to by Roy and Betty Crowson (some 2,670 records spanning 1954-1998), and a further 10,000 records from that period were gleaned from Roy Crowson's field diaries, work which is still in progress, but which is expected to bring the total to around 50,000 records.

With the help of BLB funding, the Society has run two successful hoverfly identification courses in conjunction with the national Hoverfly Recording Scheme, the Hunterian Museum and Glasgow Museums. Recently, in conjunction with BRISC (Biological Recording in Scotland) the Bequest has offered bursaries towards the costs of species identification courses such as those run by the Field Studies Council.

Grants have also been given for the purchase of the 'Recorder' database software by members of the Society, and for attending training courses in its use. The software was originally installed on a personal computer which was also funded by a BLB grant; the PC is not capable of running the latest version of Recorder, but was until recently in use by volunteers at Glasgow Museums Resource Centre for entering records into spreadsheets ready for transfer to the main database: its 11 years lifetime was pretty good for these fast-changing times.

7. UNIVERSITY OF GLASGOW STAFF-STUDENT EXPEDITIONS

The University of Glasgow's Exploration Society has a long history of organising staff-student expeditions, some to the UK but mainly overseas. These are science-based expeditions and have included projects in medicine and veterinary medicine, geology, geography and anthropology, but most have been on wildlife and conservation. The Exploration Society fell into inactivity during the period 1975-87, but was then resurrected, with the first expeditions of the re-constituted Society occurring in 1989. Raising money for Expeditions involves a great deal of fund-raising activities as well as grant applications. No single grant

is likely to fund a complete expedition, so it was very helpful when the BLB Bequest agreed that overseas expeditions would be a suitable activity to support. The first expeditions part-funded by the BLB Bequest were in 1995, and overall 59 expeditions have been supported (3.7 per year). After some debate, the Bequest Committee set a maximum of £1000 to be awarded to an expedition as a whole, not to individual participants. Awards were initially much less than that, but over the years, supported expeditions have received an average of £568.60.

Each expedition is expected to provide the Society with a report, and these are kept in the Society's Library. An on-line archive of expedition reports is in progress, and will have a link to the Society's website. For a time (2001-4) expeditions also produced a short summary for inclusion in *The Glasgow Naturalist* but this fits poorly with the expectation that *Naturalist* articles should concern mainly Scottish subjects. Another way in which expeditions have provided feedback to the Society has been via talks in the winter programme. As well as formal reports, expeditions have contributed to several Ph.D. theses, MRes and undergraduate final year project dissertations, and a substantial number of papers in refereed journals. The Society can be proud of its contributions to this work, and also to helping students gain unforgettable experiences of natural history research abroad.

8. BLB'S REQUESTS

Over the years, the suggestions made by BLB (see Introduction and Table 1) have been acted on by the Bequest Committee as thoroughly as possible.

***Projects in conjunction with the Botanical Society of the British Isles (BSBI)*:** As noted earlier, BLB funding made possible the publication of *The Changing Flora of Glasgow* (Dickson *et al.*, 2000). In addition, GNHS and BSBI contributed to the publication a checklist on the flowering plants of Argyll (Rothero & Thompson, 1994) and a flora of Tiree, Gunna and Coll (Pearman & Preston, 2000). Both are committed to supporting publication of a flora of Renfrewshire, and a flora of Lanarkshire will soon be under consideration. GNHS and BSBI also contributed to the costs of recording in the more remote upland areas of Lanarkshire for the *New Atlas of the British and Irish Flora* (Preston, Pearman & Dines, 2002).

Scouler biography: BLB gave Peter Macpherson (PM) a copy of a letter she had sent to Professor Ewan, Tulan University, New Orleans (August, 1975) which read in part "Scouleriana is now developing interest, I see in the USA, and I am hoping that the local Andersonian Naturalists Society, whose founder president he was in 1852, may after my demise, work through my papers so that they make much of the data available to USA. I propose to dispose some modest funds to them to encourage this work". In 1994, PM uplifted from Strathclyde University (on loan) a box containing the draft that BLB had typed on the life of Scouler. Over the next few years, the Bequest Committee discussed whether to publish a 'popular account', based on BLB's notes, in *The Glasgow Naturalist*, or whether a more detailed biography was desirable. After some preliminary work, it was appreciated that considerable research, some of it international, was needed for a full biography. On the suggestion of Geoff Hancock, Dr Charles Nelson, then at the National Botanic Garden, Dublin, and an experienced historian of natural history, was approached, and he agreed to take on the work. Charles Nelson worked assiduously on the task, including obtaining a copy of Scouler's notebooks from the United States, and by late 2010 had completed a manuscript of about 125 pages plus bibliography, taxa lists and illustrations. The Bequest Committee has decided to publish this valuable material in book form as a Society publication most likely in 2012. BLB's interest in Scouler included the planting of a specially grown specimen of Scouler's willow (*Salix scouleri)* in the arboretum of Glasgow Botanic Gardens (Fig. 2).

***Scott Elliot and Hennedy biographies*:** These were thoroughly researched by Eric Curtis and published in *The Glasgow Naturalist* (Curtis, 2009).

Early history of the Society: This was covered by Downie (2001) and Sutcliffe (2001) in the volume of *The Glasgow Naturalist* celebrating the Society's 150^{th} Anniversary.

The Lost Flora, Aliens and Adventives of Glasgow: These featured prominently in *The Changing Flora of Glasgow* (Dickson *et al*, 2000). This 402 page book received generous financial support from the Bequest.

Lost Flora of Helensburgh: PM made enquiries of the previous and current BSBI recorders from Dunbartonshire, Allan McG. Stirling and Alison Rutherford. BLB had told the former that John Lee had pressed a sample of every plant in Dunbartonshire and put them in matching folders. Allan had examined the herbaria of Kelvingrove Museum and Art Gallery, the University of Glasgow, and Strathclyde University. He had found a few Lee specimens but none in matching folders. PM contacted the Royal Botanic Gardens, Edinburgh, and ascertained that they held no relevant material. In the mid 1960s, Robert Mill, whist a schoolboy at Hermitage Academy, Helensburgh, surveyed the plants growing wild in the town, and later published a flora based on this work (1967). Further work on this suggestion seems unlikely to be fruitful.

Strathclyde University Herbarium Transcripts: Although this item was on BLB's list, she informed PM that it was "now in production, of interest to the Society" at Strathclyde University. However, as noted under Recording, this work is still in progress.

Strathclyde University Herbarium Catalogue: The main contributors to the herbarium were Hennedy, Scouler and Scott Elliot. Computerised cataloguing of Phanerogams was completed by Keith Watson and of

Cryptogams by J.A. McMullen (Macpherson & Watson, 1996). Computerisation of the Lichens was undertaken by Keith Watson in 2007.

Social aspects of the Society: This has been fully achieved. BLB funding has helped enhance excursions, conferences and other events, especially through provision of refreshments.

Home for the Society: Since the Bequest began, the Society has consolidated all operations into the University of Glasgow's Graham Kerr Building. The Bequest funded the provision of locked cabinets for the Society's Library, and has helped greatly with the rental costs of meeting in the Building.

Fig. 2. Blodwen Lloyd Binns planting a Scouler's willow (*Salix scouleri*) in the arboretum of Glasgow Botanic Gardens, 1988. The tree was received as a cutting from Vancouver Botanic Gardens in 1982. Present in the upper picture (left to right) are Jim Dickson, Bill Fletcher, Alex McCaw, Alastair Laurie, Ewen Donaldson, BLB and Derek Kane. The pictures were taken by Eric Curtis.

9. THE BLB LECTURE SERIES

Council agree in 2000 that it would be a good use of BLB Bequest money to fund an annual lecture series that would bring together members of the Society and the staff and students of the University of Glasgow's Division of Environmental and Evolutionary Biology (DEEB) whose Graham Kerr Building provides the Society's 'home'. The idea was that an endowed series would attract prominent ecology and evolutionary biology researchers, the modern natural historians, and that we would ask them to prepare a lecture that would interest and be accessible to both professional and amateur natural historians. The staff of DEEB gave this idea a warm welcome and the first lecture was given by Tim Clutton-Brock in October 2001. A full list of the lectures (the first 11 years of the series) is given in Table 4. The series continues in collaboration with the recently created Institute of Biodiversity, Animal Health and Comparative Medicine, successor to DEEB after the 2010 University of Glasgow restructuring.

The series began literally with a bang, since it coincided with the disastrous fire that destroyed the University's Bower (Botany) Building. Because of the emergency electrical shutdown of the University's main circuit, the lecture had to be moved at very short notice to the Western Infirmary Lecture Theatre.

Over its 11 years, the series has provided an excellent overview of modern natural history, as can be seen from the lecturers and their titles, and has consistently attracted excellent audiences. As a measure of the quality of the lecturers in the series, three of the first five were Fellows of the Royal Society, and others in the series have been elected FRS since.

CONCLUSION

It will be obvious from the foregoing accounts that the BLB Bequest's impact on the Society's activities has been immense and we are exceedingly grateful to have been the recipient of this legacy. The additional annual income of £13,000 has been a huge injection of funds for a small Natural History Society whose annual subscription income is around £3,000. Subscription income covers room hire and speakers' travel expenses for the winter programme, newsletter costs and a proportion of the publication costs of *The Glasgow Naturalist*: the remainder of the Society's activities as described here are funded by the Bequest. We feel that the income has been used imaginatively and diversely in accordance with her wishes to benefit natural history knowledge and activity at home and abroad. With continued wise management of the Bequest's investments, we anticipate that it will continue to be of benefit for years to come.

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We gratefully acknowledge Florence McGarrity's assistance in putting together and revising the several drafts of this paper; Bob Gray for providing copies of older Society accounts; and Barbara Mable for helpful comments on the penultimate draft. Ewen Donaldson kindly provided the photographs for Fig. 2 and the information about the planting of Scouler's willow.

Year	Lecturer	Title
2001	Prof Tim Clutton-Brock	Co-operation in mammals
2002	Prof Geoff Parker	Golden flies, sunlit meadows
2003	Prof Bill Sutherland	What is the future of agriculture and farmland birds?
2004	Dr Tracy Chapman	The complex mating systems of insects
2005	Prof Nick Davies	Cuckoos versus hosts: an evolutionary arms race
2006	Dr Mike Majerus	The peppered moth saga
2007	Prof Josephine Pemberton	When evolution and ecology meet: long-term studies on red deer and Soay sheep
2008	Prof David MacDonald	A brush with foxes and some other carnivore tales
2009	Prof Peter Slater	Learning about sound in animals
2010	Prof Roger Downie	Adventures with amphibians
2011	Prof Richard Abbott	Plant speciation in action in the UK: tales of the unexpected

Table 4. The BLB Lectures

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Gartcosh great crested newts: the story so far

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ABSTRACT
The Gartcosh Industrial Site, North Lanarkshire is home to the largest known population of great crested newts (*Triturus cristatus,*) in Scotland. Economic development of the site required the translocation of the great crested newt and four other amphibian species from existing ponds to a purpose built reserve around the periphery. Monitoring the effectiveness of translocation as a mitigation method has shown that in this case, the breeding adult population is being maintained at levels comparable with the previous site although there are indications of possible declines with other life stages. Longer term monitoring is required at a level more in-depth than currently planned. The aquatic and terrestrial habitat created appears sufficient to support the population although there are problems with fragmentation, both within the site and connections to external locations. There is still pressure for further development in an area that could affect the newt population.
KEYWORDS: *Triturus cristatus*, amphibians, translocation, mitigation, habitat, Scotland

INTRODUCTION

Great crested newt (*Triturus cristatus*, GCN) populations have declined across their range in Scotland (SNH Trends, 2004) and across the UK (Langton *et al*., 2001) at a rate faster than other common amphibian species throughout their entire European range (AmphibiaWeb, 2008). Habitat degradation or destruction is a significant causal factor as GCN populations are reliant upon both good quality terrestrial and aquatic habitat. Terrestrial habitats are threatened by development, urbanisation and other land use changes. The resulting fragmented populations are generally small, isolated and vulnerable to extinction (Hanski & Gilpin, 1997; Hitchings & Beebee, 1997; 1998). Aquatic habitats are at risk through deliberate destruction, lack of management and natural succession. In Scotland, the number of ponds declined during the 1950s to 1980s by 7%, although numbers were found to have stabilised during a survey in the 1990s (SNH Trends, 2004).

In the UK, GCN are protected by the Conservation *(Natural Habitats etc.)* Regulations, 1994. The regulations make it an offence to kill, injure or take the animals and to disturb them in certain circumstances. Furthermore, the legislation protects breeding sites and hibernacula. Development is the key pressure to GCN in the Scottish central belt where the known GCN populations are concentrated. Development of land containing GCN populations is only possible under licence from the local Government agency (in this case, Scottish Natural Heritage). Licenses can only be issued for specific purposes and providing the impacts of the proposal does not compromise the conservation status of the species. This normally entails the provision of a mitigation plan to ensure that impacts on individual newts, populations and habitats are minimised and, if appropriate, compensatory habitat is created or existing habitats enhanced.

The Gartcosh Industrial site in North Lanarkshire is home to the largest known GCN population in Scotland, with 1,012 adults present. This was estimated to be 9-29% of the total Scottish population (McNeill, 2010). Approval for economic regeneration of this brownfield site meant that in 2003, the Scottish Executive granted a licence for the largest GCN translocation in Scotland. However, despite a number of reviews (Oldham *et al.*, 1991; Oldham & Humphries, 2000; May, 1996 unpublished; Edgar & Griffiths, 2004; Edgar *et al.*, 2005), the question as to whether or not translocation can be an effective mitigation method remains unanswered. Some projects were doomed to failure due to poor design and implementation. Other projects were inconclusive as it was not possible to gauge success due to issues such as a lack of pre or post monitoring.

The Gartcosh translocation offered an opportunity to undertake an in-depth case study on the effectiveness of translocation as a mitigation method; what would constitute a successful translocation and how this could be achieved within the Scottish context? The research was carried out by the University of Glasgow in

consultation with North Lanarkshire Council and Scottish Natural Heritage, which also funded the research.

Development of the Gartcosh business interchange
Gartcosh former steelworks: site history
The Gartcosh Iron and Steel works was constructed between 1858 and 1872, with the rolling mill built in 1960. British Steel took over operations in 1962 until its closure and subsequent demolition in 1986. The site has since been subject to a long-term regeneration plan, including establishing motorway access, reopening the railway station and the creation of an industrial park.

Ponds developed naturally within the site and anecdotal evidence suggests that the GCN population was in residence from 1972, possibly earlier, although not known to SNH (Archibald Laing *pers. comm.)*. The site was also home to populations of *Lissotriton vulgaris* (smooth newts), *Lissotriton helveticus* (palmate newts), *Bufo bufo* (common toad) and *Rana temporaria* (common frog).
In 1998, a field survey of the site identified 13 water bodies, seven deemed suitable for GCN. The original plan had been to protect the GCN *in-situ* within the industrial park. The seven optimal ponds plus a ten hectare area of land was designated the Amphibian Conservation Area (ACA), with an additional eight new ponds dug in 1998 (Fig. 1).

An options appraisal process was then undertaken by the Gartcosh Regeneration Partnership (members included North Lanarkshire Council, Scottish Enterprise and others from the public and private sectors). They supported a regeneration 'masterplan' that incorporated economic development of the area intended as the ACA. As an alternative for the GCN, the Gartcosh Nature Reserve (GNR) would be created around the periphery of the industrial park and all captured amphibians moved from the ACA to the GNR. The GNR was completed in 2003, encompassing 24 ponds within 29 hectares of land (Fig. 2). The site was divided into three zones: Bothlin Burn (9.1Ha, 8 ponds), Garnqueen Hill (14.1Ha, 7 ponds) and Railway Junction (5.4Ha, 6 ponds). There were a further three 'Stepping Stone' ponds in the Bothlin Burn area, intended to aid dispersal.

Pre translocation monitoring: 1998-2003
Heritage Environmental Ltd (HEL) were contracted to undertake a baseline survey of the ACA for six years prior to the translocation. Torchlight surveys were used to establish annual adult counts of all five amphibian species present within the breeding ponds. Peak counts for four species were observed in 2001 (GCN: 140, palmate: 148, smooth: 161, toad: 801). The peak count for frogs (747) was recorded during 2000.

The Gartcosh translocation: 2004-2006
The translocation was undertaken by HEL, with 25% of the estimated adult GCN population in the ACA (sex ratio 1:1±10%) moved to the Railway Junction zone of the GNR during 2004 (the population estimate was based on pre-translocation monitoring). During 2005 and 2006, all GCN captured in the ACA were moved to the Bothlin Burn and Garnqueen Hill zones of the GNR. The belly pattern of an adult GCN is as unique as a fingerprint and can be used to identify individuals (Oldham & Humphries, 2000). During translocation, the belly patterns of all adult GCN were photographed and morphometric data collected (size and weight).
A total of 1,012 adult GCN were captured and moved to the GNR alongside 2,800 smooth newts, 2,705 palmate newts, 1,500 frogs and 3,168 toads. Eggs, larvae and metamorphs of all species were also translocated.

Post translocation monitoring
HEL continued to monitor peak adult counts using torchlight surveys of the breeding ponds. The University of Glasgow got involved in 2005 to 2009 with a more in-depth monitoring brief looking at key aspects including population sizes, structure and assessment of the suitability of newly created habitat to support amphibian populations.

By 2009, the results of the translocation were promising. Torchlight surveys indicated that the peak breeding GCN adult count in the receptor site was double the peak count in the donor site. This was supported by the results of a mark-recapture study undertaken, comparing post-translocation population size with the known number of adults translocated. Recruitment to the breeding population was occurring, but an examination of the juvenile life-stages highlighted possible future problems, with decreased production and survival of larvae and metamorphs (McNeill, 2010). Further study is required to ascertain whether this was a natural fluctuation or of greater concern, linked to the translocation. However this type of monitoring is not part of the on-going management/surveying plan.

The provision of good quality aquatic and terrestrial habitat of a quantity comparable to that being lost is critical to the on-going success of the translocation. For a review on what is considered 'good' habitat, see McNeill (2010). There has been a significant reduction in available terrestrial habitat when comparing the original Industrial Site (86Ha) to that made available for the GNR (29Ha), although only a proportion of the Industrial site could be considered to have been 'newt-friendly'. However, the GNR has a considerably larger area of good terrestrial habitat if compared directly with the ACA (10Ha).
There was an increase in the number of ponds created as part of the GNR but an overall decrease in pond surface area. This was avoidable, the result of a number of ponds dug that were below the recommended size threshold for GCN suitability described as 100 m^2 minimum (English Nature, 2001) and 250 m^2 as the optimum (Gent & Gibson, 2003). The entire Railway Junction zone was of sub-optimal size.

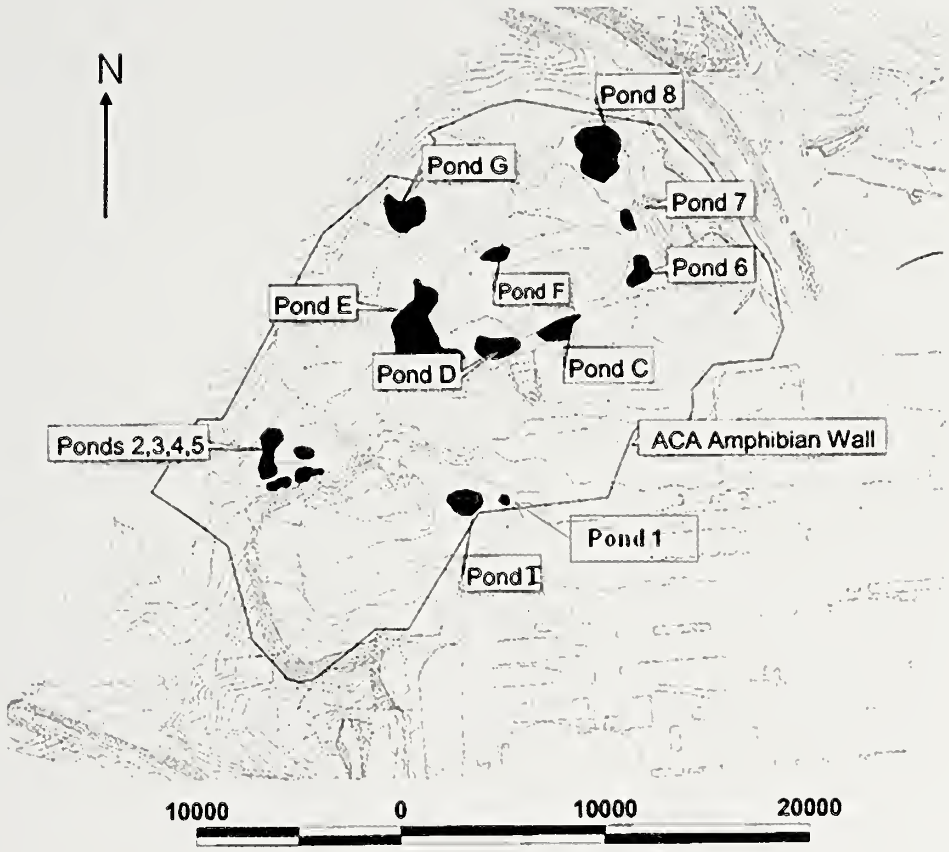

Fig. 1. Amphibian Conservation Area (ACA). Includes six of the seven original ponds, labelled C,D,E,F,G,I. Pond L is not shown on this map. The eight newly created ponds are also shown, labelled 1-8. Map reproduced with permission from Ironside Farrer. Modified to show the location of Pond 1.

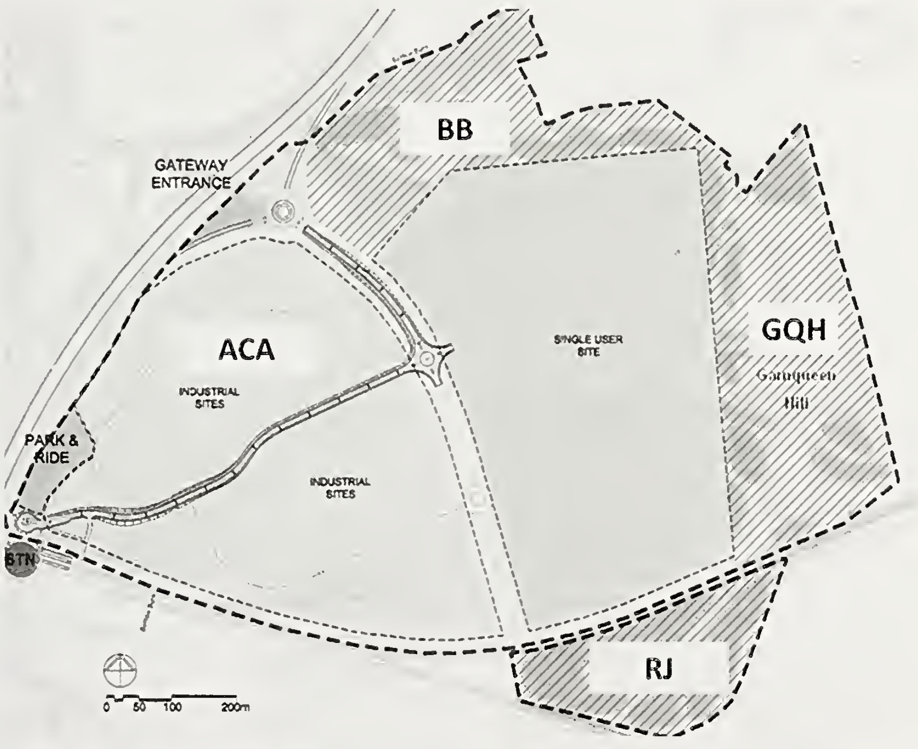

Fig. 2. Map of the Garteosh Industrial Site. The locations of the donor Amphibian Conservation Area (ACA) and the newly created Garteosh Nature Reserve are shown. The reserve by line hatchings, with labels showing the position of the three zones Bothlin Burn (BB), Garnqueen Hill (GQH) and Railway Junetion (RJ). Modified from a map provided by Seottish Enterprise.

Habitat quality was determined using a combination of measures including the GCN Habitat Suitability Index (Oldham *et al.* 2000), aquatic macrophyte sampling, macroinvertebrate analyses (Biggs *et al.*, 1998) and interpretation of terrestrial records provided by Ironside Farrer who undertook the habitat creation works. Analyses indicated that the GNR habitat was of good quality, capable of supporting the GCN population (McNeill, 2010). Notably, the Habitat Suitability Index scored the GNR higher than the ACA (McNeill, 2010). This is based on ten metrics incorporating data from both the aquatic and terrestrial habitat. The higher the score, the more suitable a habitat is for GCN occupation.

The GNR was fragmented for its initial years due to the provision of ring fencing around each of the individual zones (McNeill, 2010). Dispersal throughout the site remains problematic, with limited migration corridors. Of particular concern is the Railway Junction zone as only 56 adults were originally translocated there, below the minimum viable breeding population size described as 40 females (Halley *et al.*, 1996) or minimum of 100 adults (Shaffer, 1981; Griffiths and Williams, 2000; 2001). Garteosh remains isolated within a fragmented landscape. This was not as a result of the translocation. The nearest known population is in Drumcavel Quarry, outwith the range of natural migration and separated by a motorway. The lack of immigration is a threat to the long term viability of the Garteosh population.

CONCLUSIONS

The story so far at Garteosh is one of short-term success with further study required to ascertain whether the population will be self-sustaining in the long-term. The monitoring brief post-2009 is not comprehensive enough to provide the required long term data, consisting primarily of peak breeding adult counts. While this provides useful information on annual population fluctuations, it does not detail crucial information relating to population size, survival and recruitment.

There is considerable development pressure in the area around Garteosh. This development has the potential to impact directly on the Garteosh Nature Reserve, but also more widely on potential movement of newts through the wider countryside. It is important that the consideration of any development proposals in the area take the great crested newt population at Garteosh into account and that they are designed to minimise impacts and even promote free movement of the population.

The decision to relocate to the GNR instead of protecting the newts *in-situ* was taken because of the economic imperative to develop the ACA along with the rest of the Industrial Site. The development of the site has been relatively slow but is now gathering speed. Great crested newts may still be present in some areas of the site due for development and it is essential that their presence is considered as part of this work.

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Vegetation and 'site florulas' of islands in West Loch Roag, Outer Hebrides

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ABSTRACT
Four small, uninhabited islands in West Loch Roag, a sea loch in the west of the island of Lewis, Outer Hebrides, were visited in early July 2008, two grazed – Flodaigh and Campaigh, and two ungrazed – Bearasaigh and Seana Cnoc. The habitats present and the interesting species are discussed, and the limited floras ('florulas') of each island are described, with full species lists. The species recorded for Campaigh are compared with a visit to the same island 30 years earlier.

INTRODUCTION

There are many small islands in Loch Roag, a series of sea lochs in the west of Lewis, Outer Hebrides at approx 58° 16'N 6° 54'W (NB14 on the British National Grid). In spite of the draw of islands for visitors, they have only rarely been visited in the history of botanical recording in the Outer Hebrides, if at all. Currie (1981) reports a visit in 1977, when several islands were circumnavigated, but a landing was made only on Campaigh (Campay), NB1442. A list of the plant species was made, and this gives us a baseline with which to eompare.
On 3 July 2008 as part of recording for a projected tetrad (2km×2km square) flora of the Outer Hebrides a visit was made to several of the islands – Flodaigh (NB1241), Bearasaigh (NB1243), Seana Cnoc (Old Hill) (NB1143) and Campaigh (NB1442). It proved impossible to land on two smaller islets, Hairsgeir (NB14A) and Mas Sgeir (NB1443).

The islands and their vegetation

Two of the four islands visited, Flodaigh and Campaigh are low-lying with relatively easy access, and therefore used for sheep grazing. They have short, well-cropped turf, but there are a few refugia on less sheep-friendly habitat (coast, rocks, pebbles) where plants less tolerant of grazing (for example *Aster tripolium* (sea aster) on Flodaigh) can grow. Bearasaigh and Seana Cnoc, by contrast, have steep rocky sides; they are grazed, but only by geese (which in places make paths) and therefore at a much lower intensity than the sheep, and in consequence they have well-developed tussocks and hummocks, with some *Armeria maritima* (thrift) tussocks becoming very large (Fig. 1). They also have much more cliff habitat and therefore some different species.

Fig. 1. Large *Armeria maritima* (thrift) tussocks on the NW plateau of Bearasaigh.

There are three broad communities on the four islands visited. Much of the flatter surfaces of the tops is covered by a plantain sward, containing *Plantago coronopus*, *P. lanceolata* and *P. maritima* (buck's-horn, ribwort and sea plantain respectively), and also with varying amounts of *Armeria maritima* and grasses. On the sheep-grazed islands the sward is grazed very short, but otherwise it grows into tussocks and forms a maritime peat. In this habitat there are also occasional species such as *Ophioglossum vulgatum* (adder's-tongue fern) (Flodaigh), and where there is no grazing *Silene uniflora* (sea campion) (Bearasaigh and Seana Cnoc). Seana Cnoc has an area dominated by *Rumex acetosa* (sheep's sorrel) forming a turf.
The sides of the islands, whether steep cliffs or smaller, sloping rocks have a different community, with *Aster tripolium*, *Ligusticum scoticum* (Scots lovage), *Silene uniflora*, and *Tripleurospermum maritimum* (sea mayweed).
Flodaigh and Bearasaigh both have small, permanently wet depressions. On Bearasaigh the edge of the depression has *Ophioglossum vulgatum*, and on Flodaigh there is a small amount of *Apium inundatum* (lesser marshwort). Both these islands also have *Ranunculus flammula* (lesser spearwort) in the damp areas, but on Bearasaigh there is also the small variety of this species with very round leaves, *R. flammula* ssp

minimus which is characteristic of damp patches in very exposed situations near the sea.

The most interesting species, abundant on all four of the visited islands, was *Lychnis flos-cuculi* (ragged robin), which was scattered throughout the turf. This is a much shorter variety than the usual one of marshy areas, with the flowers forming a dense cluster at the top of the short stem and with wide petals, and it is unclear what the appropriate name for this variety is (although it may be forma *pygmaea* Ostenf., see Jonsell 2001, p178). It is known from other islands in the Sound of Harris (Heslop Harrison 1954, 1956). On Seana Cnoc there were two colour forms – most specimens the usual deep pink, with a few much paler (but not quite white).

The rocks round Flodaigh, Bearasaigh and Seana Cnoc all have *Aster tripolium* (sea aster), as var *condensatus*, a fleshy-leaved plant of rocky places which looks quite different from the more usual var *tripolium* on salt marshes. On Flodaigh it occurs in small quantity, on coastal rocks where there is protection from grazing. On Bearasaigh the absence of sheep has allowed the *Aster* to thrive away from the rocks, and it has colonised in bare peaty pools and hollows, so it is common on the top of the islands as well as round their coasts.

Site Floras

The Botanical Society of the British Isles has been suggesting the concept of *site floras*, a description of the plants for relatively small, well-defined sites that can be visited regularly with a reasonable degree of coverage (Lockton 2007). It is generally difficult to define such sites in the Outer Hebrides away from habitation, but islands form natural sites, though with small floras ('florula'). They will generally be covered by only a single visit, but these visits are much more likely to be recorded than visits to mainland sites of comparable size. Since it is sensible to follow up existing site descriptions, we provide a site florula for Campaigh, and we also give initial descriptions for the other islands visited as a baseline for future visits. Summary information is given in Table 1.

Site florula for Campaigh

Campaigh is approximately 500m long and 250m across at its widest, and rises to just over 30m above sea level at its highest. It runs roughly from SW to NE, with the SW end being lower and shelving to low rocky sides; the NE end is separated from the rest of the island by a natural arch, and has some cliffs. The underlying rock is gneiss (Fettes *et al.* 1992), although the arch is presumably formed by erosion of a softer dyke. The island is turf-covered away from the rocky and cliffy edges, and grazed throughout by sheep. The cliff parts are used by nesting seabirds, and there is some evidence of eutrophication from their use of the island. There is no standing water.

A list was published for Campaigh by Currie (1981) from a visit of "an hour or two" on the evening of 23 June 1977, apparently for bird counting as well as botany. The authors of the present paper visited for one hour on 3 July 2008, a very similar time of the year to the previous visit, and our attentions were more exclusively botanical. Currie commented that some species could be added to his list, and although we have made a nearly complete list, it is likely that a few species still lurk undetected.

The taxa recorded on 3 July 2008 are listed in Table 2, with a * denoting that they were also recorded by Currie

Nine species were recorded in 2008 but not seen during the visit in 1977; they are generally less conspicuous species such as the *Euphrasia* (eyebright) which was in small quantity as non-flowering plants, and *Sagina maritima* (sea pearlwort) which is an annual of bare peaty patches near the sea. The most obvious of the species present in 2008 but not recorded in 1977 was *Spergularia rubra* (sand spurrey), which was abundant in barer patches at the western end of the island. It is interesting to speculate that both the bare patches and presence of *Spergularia* are connected with the sheep grazing, although Currie noted grazing in 1977 too.

Currie additionally recorded *Aira praecox* (early hair-grass), *Asplenium marinum* (sea spleenwort), *Carex panicea* (carnation sedge), *Festuca ovina* (sheep's fescue) and *Tripleurospermum maritimum*. Any of these could still be present and overlooked, but particularly *Tripleurospermum* is very obvious and it seems likely that this has declined.

Island	Maximum Dimensions (length × breadth × height) (m)	Approx area (ha)	Time spent recording (hrs)	Grazing	Taxa recorded	Taxon density (taxa ha^{-1})
Bearasaigh	400 × 250 × 58	9.8	1½	geese (v light grazing)	49	5.0
Campaigh	500 × 250 × 30	10.2	1	sheep (heavy grazing)	34	3.3
Flodaigh	450 × 400 × 22	18.6	¾	sheep (heavy grazing)	66	3.5
Seana Cnoc	600 × 300 × 90	11.1	1¼	geese (v light grazing)	28	2.5

Table 1. Summary information on islands visited on 3 July 2008.

Site florula for Bearasaigh

Bearasaigh (Fig. 2) is a steep-sided island with cliffs most of the way round. Its summit is 58m, and the top of island forms a plateau, sloping down slightly to the north-west, sloping more steeply to around 30m in the east. Its longest axis runs roughly NW to SE, about 400m long, and it is about 250m wide at its widest. There is a stac to the SW, Stac an Tùill, but this was not visited. The underlying rock is gneiss (Fettes *et al.* 1992). The NW part of the island consists of a tussocky maritime heath, with very large *Armeria* tussocks (Fig. 1), and a few boulders, many with temporary pools at their bases. The SE part is more grassy, with one permanent pool.

Fig. 2. Bearasaigh looking at the NW end, with Stac an Tùill to the right, and Flodaigh the lower island behind the Stac.

Bearasaigh was visited on 3 July 2008 for 1½ hours; coverage was good at the western end where we landed, but more rushed at the eastern end, and it is likely that additional searching will turn up a few extra species here too. 49 taxa were recorded (see Table 2)

Site florula for Seana Cnoc

Seana Cnoe (Fig. 3) is another steep-sided island, basically a long ridge running almost E to W, its edges a combination of cliffs and very steep vegetated slopes. It is about 600m long, and 300m wide and is the tallest of the islands visited, with a summit just over 90m. The underlying rock is gneiss (Fettes *et al.* 1992). Seana Cnoc is a dry island without standing water, and without the peaty pools found on Bearasaigh. It is predominantly grassy with a mainly *Festuca rubra* (red fescue) turf, with abundant *Lychnis flos-cuculi* and *Silene uniflora.*

Fig. 3. Seana Cnoc, looking at the South side.

Seana Cnoc was visited on 3 July for 1¼ hours. Since the variety of habitats was smaller than on the other islands visited, it is likely that a reasonably comprehensive list was obtained. 28 taxa were recorded (see Table 2).

Site florula for Flodaigh

Flodaigh (Fig. 2) is a low-lying, sheep-grazed island, with a variety of habitats. It has an irregular outline with several geos, and at its largest is about 450m long and 400m wide. The bay on the south side that faces the islet of Tamna was formed by a pebble beach, partly vegetated, and there was a small permanent pool in the peatier ground some way to the north of this. Much of the turf was damp and peaty. The underlying rock is gneiss (Fettes *et al.* 1992).

We had a short visit of only ¾ hour to Flodaigh on 3 July 2009. This was therefore the least well covered of the islands discussed here, with nearly all the effort on the eastern part, and it is likely that several additions could be made to the species list with a longer visit. Nevertheless it had the greatest diversity of the islands visited, with 66 taxa recorded (see Table 2).

DISCUSSION

The limited number of habitats on small islands means that the numbers of species found was small relative to the main islands of the Outer Hebrides. 20 species were common to all four islands, all of them common and widespread in exposed coastal habitats in the Outer Hebrides. Additional species are found according to the different habitats present, and presumably their occurrence is also affected by how easily seeds can reach isolated islands. Some species are likely to have come in with sheep as they are moved to and from the grazed islands, and *Spergularia rubra* may be an example of this type of translocation.

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Species	Campaigh	Bearasaigh	Seana Cnoc	Flodaigh
Agrostis stolonifera	✓*	✓	✓	✓
Aira praecox			✓	✓
Alopecurus geniculatus		✓		
Anagallis tenella				✓
Angelica sylvestris		✓		
Anthoxanthum odoratum				✓
Apium inundatum				✓
Armeria maritima	✓*	✓	✓	✓
Aster tripolium var *condensatus*		✓	✓	✓
Atriplex sp.	✓*	✓	✓	✓
Bellis perennis				✓
Callitriche sp.		✓		
Calluna vulgaris				✓
Cardamine pratensis				✓
Carex flacca		✓		✓
C. nigra	✓	✓		✓
C. ovalis				✓
C. viridula ssp *oedocarpa*				✓
C. viridula ssp *viridula*	✓*	✓		✓
Cerastium diffusum		✓		
Cerastium fontanum	✓*	✓	✓	✓
Cirsium vulgare				✓
Cochlearia officinalis s.l.	✓*	✓	✓	✓
Dactylorhiza maculata		✓		✓
Dactylis glomerata		✓		
Danthonia decumbens	✓			✓
Deschampsia cespitosa		✓		
Eleocharis palustris				✓
Empetrum nigrum		✓		
Erica cinerea				✓
Eriophorum angustifolium		✓		✓
Euphrasia foulaensis				✓
Euphrasia officinalis agg.	✓	✓		✓
Festuca rubra s.l.	✓*	✓	✓	✓
Galium aparine				✓
Glaux maritima	✓*			✓
Holcus lanatus	✓*	✓	✓	✓
Hydrocotyle vulgaris	✓*	✓		✓
Juncus articulatus		✓		✓
Juncus bufonius s.s.	✓	✓		✓
Juncus bulbosus		✓		
Leontodon autumnalis	✓*		✓	✓
Leontodon autumnalis var *autumnalis*		✓		
Ligusticum scoticum		✓	✓	✓
Lotus corniculatus	✓*	✓	✓	✓
Luzula multiflora ssp *multiflora*				✓
Lychnis flos-cuculi	✓*	✓	✓	✓
Montia fontana ssp *fontana*			✓	✓
Nardus stricta				✓
Ophioglossum vulgatum		✓		✓
Plantago coronopus	✓*	✓	✓	✓
Plantago lanceolata	✓*	✓	✓	✓
Plantago maritima	✓*	✓	✓	✓
Poa annua	✓			
Poa humilis	✓*	✓	✓	✓
Poa trivialis				✓
Potentilla anserina				✓
Potentilla erecta				✓
Primula vulgaris				✓
Prunella vulgaris		✓		✓
Puccinellia maritima	✓	✓	✓	✓

Ranunculus acris	✓*	✓	✓	✓
Ranunculus ficaria ssp *ficaria*		✓	✓	✓
Ranunculus flammula		✓		✓
Ranunculus flammula ssp *minimus*		✓		
Rumex acetosa	✓*	✓	✓	✓
Rumex crispus	✓*	✓		✓
Sagina maritima	✓			
Sagina procumbens	✓*	✓	✓	✓
Sedum rosea		✓	✓	
Selaginella selaginoides				✓
Silene uniflora	✓*	✓	✓	✓
Spergularia rubra	✓			
Stellaria media	✓*		✓	✓
Succisa pratensis		✓		✓
Thymus polytrichus	✓*	✓		✓
Trifolium repens	✓*	✓	✓	✓
Triglochin maritimum	✓			
Tripleurospermum maritimum		✓	✓	✓
Urtica dioica				✓
Viola riviniana				✓

Table 2. Species recorded in the four islands on 3 July 2008; * denotes species also recorded for Campaigh by Currie (1981).

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A review of the incidence of cyanobacteria (blue-green algae) in surface waters in Scotland including potential effects of climate change, with a list of the common species and new records from the Scottish Environment Protection Agency

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ABSTRACT

Cyanobacteria, commonly known as blue-green algae, are a ubiquitous component of the freshwater microflora. Cyanobacteria are capable of producing toxic compounds that pose a risk to water-users, pets and livestock, with increased risk when they form dense growths, termed blooms, which may accumulate at the leeward shores of water bodies, often forming visible scums. The Scottish Environment Protection Agency receives numerous water samples annually for algal analyses, including determining the presence or absence of cyanobacteria, which are used in the management of risk to water users by water owners, local Councils and Health Authorities. The commonest cyanobacterial taxa recorded over the period 2008-2010 are detailed, along with new cyanobacterial records for Scotland. The current scenarios of climate change predict an overall increase in phytoplankton biomass, with potential increased dominance of cyanobacteria including increased intensity and frequency of blooms.

INTRODUCTION

Cyanobacteria are ubiquitous and contribute to the natural community of photosynthetic microscopic algae living in fresh waters. Cyanobacteria are more commonly referred to as blue-green algae due to the colour of the cells, which contain a mixture of photosynthetic pigments including chlorophyll (green), phycocyanin (blue) and sometimes phycoerythrin (red).

Excessive growths of cyanobacteria, termed blooms, have been related to the elevated nutrient status of water bodies (Reynolds and Petersen, 2000), to a number of seasonal factors (warmer temperatures, intensity of water thermal stratification) (Reynolds, 2006), to high alkalinities and pH (Shapiro, 1984), and to a number of physiological adaptations and mechanisms (Fogg, 1969; Reynolds, 1987; Shapiro, 1990). Carvalho *et al.* (2011) found that low water colour and neutral-alkaline conditions were the significant explanatory variables in determining which water bodies in the UK were vulnerable to cyanobacterial blooms, with increasing retention time and total phosphorus concentrations being borderline significant explanatory variables.

Certain cyanobacteria are able to form surface blooms through the regulation of their buoyancy by the use of gas vesicles, and such blooms may be restricted to the surface layers of the water. Light winds may concentrate the blooms to further accumulate and form scums, which may be extremely dense at leeward shores, bays and inlets, often where members of the public identify the problem, though when wind speeds increase the blooms disperse within the deeper water layers. Consequently blooms may form and disappear rapidly, within hours, due to variable weather conditions. Blooms are commonest during the summer, persisting into late-autumn, and are of concern to many water users as well as a danger to pets and livestock when the excessive growths and concentrations of cyanobacteria result in dense surface and shore-line scums. This is because cyanobacteria have the potential to produce toxins, and cyanotoxin production is much greater where cyanobacteria accumulate and form surface blooms and scums.

The different types of cyanotoxins produced by cyanobacteria and their mode of action have been widely documented (Chorus and Bartram, 1999). Cyanotoxins include neurotoxins, hepatotoxins, lipopolysaccharides, and a wide range of other products leading to enzyme inhibition and skin and gastrointestinal irritations (Chorus and Bartram, 1999). The exposure routes of cyanotoxins are diverse, mainly through ingestion, inhalation and skin contact. Exposure to cyanotoxins is therefore greatest during participation in water-based recreational activities. However, cyanotoxins may also be taken up directly through food consumption (Funari and Testai, 2008; Murch *et al.*, 2004). Symptoms produced by cyanotoxins can be mild (skin irritations and gastrointestinal illness), serious (acute poisoning and potential long-term illness) or terminal (death) (Chorus and Bartram, 1999). Cyanotoxins may also pose an

additional threat due to their carcinogenic properties (Falconer, 2005). Furthermore, the issue of toxicity is complicated by the occurrence of both toxic and non-toxic strains within the same species of cyanobacteria. However, a high percentage (59%) of all samples are toxic (Chorus and Bartram, 1999).

Cyanobacterial blooms and associated toxicity have been reported worldwide over the years (Francis, 1878; Metcalf and Codd, 2004) and although previously limited in frequency, in recent decades the frequency, intensity and reporting of cyanobacterial blooms has become widespread (Krokowski and Jamieson, 2002; Carmichael, 2008). There continue to be reports of animal deaths and skin irritation in humans associated with algal and cyanobacterial blooms and scums throughout Scotland (Scottish Government, 2007; Krokowski, 2009), although objective evidence is difficult to obtain to confirm an association with cyanotoxin exposure. A number of Scottish freshwater bodies, however, continue to be perennial 'hot spots' containing high concentrations of cyanobacteria throughout summer and into autumn.

Cyanobacteria are therefore arguably the most visible symptoms of eutrophication (nutrient enrichment) of surface waters, and there is growing concern about the likely increase in the frequency and intensity of cyanobacterial blooms associated with global warming (Mooij *et al.*, 2005).

ASSESSMENT OF CYANOBACTERIA-RELATED BLOOMS AND SCUMS IN SCOTTISH FRESHWATER BODIES

Background

A comprehensive inventory of standing freshwaters derived from Ordnance Survey digital map data in Great Britain identified 25,615 water bodies in Scotland with surface area larger than $0.01 km^2$ (Hughes *et al.*, 2004). The majority of these are in north-west Scotland. The data set contains no water bodies <$0.0002 km^2$, with the numbers between $0.0002 km^2$ and $0.002 km^2$ almost certainly under-represented so numbers may be closer to 31,460 standing water bodies as identified earlier (Lyle and Smith, 1994). It is therefore impossible to accurately assess the extent of cyanobacterial blooms and scums in Scottish freshwater bodies, as there is no comprehensive survey of all freshwaters. Moreover, a reactive monitoring strategy has been adopted where samples are received for analysis from external sources from sites with a perceived visual algal problem.

In 1997, the Scottish Environment Protection Agency (SEPA) carried out an assessment of a selected number of lochs (based on size, amenity value and recreational potential) to assess the degree of eutrophication through the prevalence of cyanobacterial blooms (SEPA, 1999). The results are not representative of the total incidence of blooms across water bodies in Scotland, but of the 77 lochs monitored, 38 had a cyanobacterial scum present and an additional 20 lochs had cyanobacteria present at sufficient levels for bloom formation (this level is taken to be equivalent to more than 20,000 cyanobacterial cells/ml). A subsequent assessment of eutrophication in 2005, carried out as part of statutory review of eutrophication under the Urban Waste Water Treatment Directive, identified 17 lochs with excessive nutrient levels (primarily phosphorus) (SEPA, 2005). Although cyanobacteria were not monitored directly during the 2005 assessment, criteria selected were based on the exceeding of set thresholds of total phytoplankton biomass measured as chlorophyll *a*, as well as the exceeding of set thresholds for nutrient concentrations (nitrogen and phosphorus) and other selected attributes and biota (dissolved oxygen, macrophytes).

Algal and cyanobacterial assessment during 2008-2010

SEPA, amongst its other duties, continues to carry out surveillance monitoring in response to environmental legislation and is able to provide an analytical service for the analysis of algae and cyanobacteria. SEPA, however, does not carry out targeted monitoring and assessment for frequency and intensity of cyanobacteria, but relies on others to provide samples from affected waters that are perceived to pose a risk to water users.

Samples received by SEPA are normally collected from a point on the downwind shore of the water body where the concentration of cyanobacteria is greatest. If the downwind site is inaccessible, the water body is sampled at the nearest accessible point to the downwind shore. Details of sampling and location are provided to SEPA. Algae are sampled at or just below the water surface, and benthic algae are occasionally also collected. A full sampling protocol is detailed in the Scottish Government guidance (Scottish Government, 2007). Live samples are sent as quickly as possible to local SEPA laboratories for analysis (Aberdeen, Dingwall, Perth, Edinburgh, Galashiels, East Kilbride and Dumfries). Standard operating procedures are used by SEPA to quantify the type of cyanobacteria present, and their abundance is reported against the World Health Organisation guidance levels (Scottish Government, 2007). Microscopic analysis is carried out with identification to species level where possible, and algae and cyanobacteria are identified with the aid of taxonomic guides and keys (John *et al.*, 2011; Komarek and Anagnostidis, 1999, 2005). Results are generally reported the same day.

Information on cyanobacteria samples received from such assessment over the period 2008-2010 is summarised in Table 1, with a list of the common cyanobacteria and new records from Scottish freshwater bodies detailed in Table 2.

In the period 2008-2010, a total of 422 samples was received by SEPA and analysed for the type of algae present and their abundance (Table 1).

SEPA Ecology laboratory	2008 Total number of samples received	2008 Number exceeding cyanobacterial threshold, expressed as % of the total	2009 Total number of samples received	2009 Number exceeding cyanobacterial threshold, expressed as % of the total	2010 Total number of samples received	2010 Number exceeding cyanobacterial threshold, expressed as % of the total
Aberdeen	23	5 (22%)	29	12 (41%)	27	14 (52%)
Dingwall	8	4 (50%)	5	2 (40%)	8	4 (50%)
Perth	66	37 (56%)	36	11 (31%)	24	10 (42%)
East Kilbride	83	17 (20%)	63	13 (21%)	45	31 (69%)
Edinburgh and Galashiels	1	1 (100%)	5	5 (100%)	6	4 (67%)
Dumfries	0	0	9	4 (44%)	20	7 (35%)
All combined	**181**	**64 (35%)**	**147**	**47 (32%)**	**130**	**70 (54%)**

Table 1. Summary of the annual number of samples received by each SEPA Ecology laboratory for algal analysis from the reactive monitoring programme. Detailed are number of samples exceeding the cyanobacterial concentrations of 20,000 cells/ml (representing a relatively low probability of adverse health effects) and expressed as a percentage of the total number of samples received.

Order	Cyanobacteria taxon	Frequency
Chroococcales	*Aphanocapsa* Nageli 1849	F
	Aphanothece Nageli 1849	F
	A. minutissima (W.West) Komarkova-Legnerova et Cronberg 1994	R
	Chroococcus limneticus Lemmermann 1898	O
	Coelosphaerium kuetzingianum Nageli 1849	O
	Gomphosphaeria aponina Kutzing 1836	O
	Merismopedia Meyen 1839	O
	M. warmingiana Lagerheim 1883	R
	Microcystis Kutzing 1833 ex Lemmermann 1907 nom.cons	F
	M. wesenbergii (Komarek) Komarek in Kondrateva 1968	O
	Radiocystis geminata Skuja 1948	R
	Snowella Elenkin 1938	O
	S. atomus Komarek et Hindak 1988	N
	S. septentrionalis Komarek et Hindak 1988	N
	Synechococcus Nageli 1849	O
	Woronichinia naegeliana (Unger) Elenkin 1933	F
	W. karelica Komarek et Komarkova-Legnerova 1992	N
Oscillatoriales	*Oscillatoria* (Vaucher 1803) Gomont 1892	F
	O. tenuis (C.Agardh 1813) Gomont 1892	O
	Planktothrix agardhii (Gomont) Anagnostidid et Komarek 1988	F
	P. isothrix (Skuja) Komarek et Komarkova 2004	O
	Pseudanabaena Lauterborn 1914-17	F
	P. limnetica (Lemmermann) Komarek 1974	O
Nostocales	*Anabaena* (Bory 1822) Bornet et Flahault 1886	F
	A. affinis Lemmermann 1897	O
	A. catenula (Kutzing 1849) Bornet et Flahault 1886	O
	A. circinalis (Rabenhorst 1852) Bornet et Flahault 1886	F
	A. flos-aquae ((Lyngbye) Brebisson 1835) Bornet et Flahault 1886	F
	A. spiroides (Klebahn 1895)	F
	Aphanizomenon flos-aquae ((Linnaeus 1753) Ralfs 1850) Bornet et Flahault 1886	F
	A. gracile Lemmerman 1910	O
	Gloeotrichia (J.Agardh 1842) Bornet et Flahault 1886	F
	G. echinulata (J.E.Smith) P.G.Richter 1894	F

Table 2. Cyanobacterial taxa recorded from Scottish freshwaters as part of SEPA's algal analysis, indicating frequency – F (frequent), O (occasional), R (rare) and N (new – requiring further verification).

No clear trend was evident in the incidence and frequency of cyanobacteria over the three-year period. The highest numbers of samples were received by East Kilbride and Perth laboratories, whereas the lowest numbers of samples were received by laboratories in Edinburgh and Galashiels. No samples were received by Dumfries laboratory in 2008.

The proportion of samples analysed and found to contain cyanobacteria exceeding the threshold concentration of 20,000 cells/ml also varied between the laboratories and over the years, but in general over one third of samples analysed contained cyanobacteria at concentrations above the threshold value.

In total, 33 cyanobacteria taxa from 17 genera were recorded from Scottish fresh waters (Table 2), with the most frequent toxin-producing cyanobacteria genera recorded as *Aphanocapsa*, *Aphanothece*, *Microcystis*, *Woronichinia*, *Oscillatoria* (*Planktothrix*), *Anabaena*, *Aphanizomenon* and *Gloeotrichia* (Table 2.). Cyanobacteria species not previously recorded from Scotland are also detailed, and include records from SEPA's phytoplankton monitoring carried at a number of lochs (>1km^2) across Scotland over the summer months (July to September) as required under the Water Framework Directive (European Commission, 2000). The WFD-related monitoring results are not detailed here in full, but of note are new records for *Snowella atomus*, *S. septetrionalis* and *Woronichinia karelica*. A number of these records require confirmation, if possible from live material, due to the very small dimensions of the cells and colonies and difficulties in correctly identifying the taxa from Lugol's iodine preserved material.

DISCUSSION

The 2008-2010 assessment

It is difficult to identify trends in the frequency and intensity of cyanobacteria across Scottish freshwaters based on the results presented here, mainly because they are based on subjective monitoring, since only sites that have a perceived algal problem are investigated. Furthermore, sites that have perennial cyanobacterial problems may not have been monitored in subsequent years. It is likely that visible warning signs of the presence of high concentrations of cyanobacteria in the water may be a deterrent in itself, and avoid the need to provide samples for analysis. However, the service provided by SEPA for the assessment of algae and cyanobacteria is crucial in providing an early detection system for the presence of potentially toxic species enabling appropriate monitoring and remedial action to be taken, not only for cyanobacteria (local algal action plan), but also for other algal groups (*Chrysochromulina*, Krokowski, 2009).

Empirical evidence indicates a direct positive relationship between increasing external load of nutrients and algal biomass, although each water body is unique (Vollenweider and Kerekes, 1982). In attempts to control eutrophication and its symptoms (such as excessive algal and cyanobacterial biomass) the most widely accepted and employed option is to reduce nutrient inputs, which has to be part of a long-term restoration and management strategy (Sas, 1989). The long-term restoration may also include methods aimed at reducing in-lake nutrient concentrations, controlling nutrient sources from sediments, and controlling in-lake levels of algae and cyanobacteria. Any future management options to control eutrophication, and the abundance of potentially toxic cyanobacteria, should be carefully assessed with a detailed restoration and management action plan.

Management of the health risks posed by cyanobacteria

To help provide effective management of the health risks associated with the exposure of humans and animals to cyanotoxins, the Scottish Government has produced guidance for the assessment and minimisation of risks to public health in inland and inshore waters (Scottish Government, 2007). Guidance adopted following equivalent guidance provided by the World Health Organisation (Chorus and Bartram, 1999) produced guideline values based on cyanobacterial abundance for recreational waters, relating them to a relatively low probability of adverse health effects (cyanobacterial concentrations of 20,000 cells/ml), moderate probability of adverse health effects (cyanobacterial concentrations of 100,000 cells/ml), and high probability of adverse health effects (where cyanobacterial scum is present). As an additional precaution, the guidance adopted in Scotland is at the lower level of risk, at the limit of 20,000 total cyanobacterial cells/ml at which bathing should be discouraged and the hazard investigated further, on-site risk advisory signs posted, relevant authorities informed, and mindful watch kept out for scum conducive conditions.

The Scottish Government guidance includes the development, implementation and coordination of local blue-green algae monitoring and action plans involving a number of organisations and stakeholders, aimed at identifying, inspecting and monitoring those water bodies most at risk of cyanobacteria, and providing remedial and preventative measures as well as providing information to the public. SEPA is one such organisation involved in helping to develop local action plans and able to provide an analytical service to identify and quantify algae and cyanobacteria from water samples. SEPA also contributes to the surveillance of environmental incidents as recorded via the Scottish Environmental Incident Surveillance System.

Potential effects of climate change

Climate change may pose significant and extreme threats to the phytoplankton community structure and hence to the ecological status of Scottish freshwater bodies. Modelled increases in annual air temperatures (IPCC, 2007) would give rise to increased water

temperatures, and with high summer temperatures predicted there could be prolonged periods of thermal stratification of relatively deep water bodies. Predicted increases in rainfall would also increase nutrient run-off. Consequently, modelling predicts an increase in phytoplankton biomass, potentially increased dominance of cyanobacteria, and increased intensity and frequency of cyanobacterial blooms (Wagner and Adrian, 2009). The effects of warming on increasing cyanobacterial biomass, and frequency and intensity of blooms may however be more pronounced in relatively deeper, stratified water bodies, where there are relatively fewer macrophytes and where phytoplankton dominance is established (Moss *et al.*, 2003).

There are also likely to be expansions of warm-water species at the expense of cold-water species, with potential expansion of invasive cyanobacteria such as *Cylindrospermopsis raciborskii* (Wiedner *et al.*, 2007). *C. raciborskii* has spread from the tropics to temperate zones over recent decades and is now found in most northern European water bodies. *C. raciborskii* has the potential to produce toxins harmful to animals and humans (a neurotoxin saxitoxin and hepatotoxin cylindrospermopsin). There are currently no known records *of C. raciborskii* in Scotland, but if the succession of warmer summers continues it is likely that it may be recorded in the British Isles. The new phytoplankton taxa already recorded in the British Isles may reflect climate change or the increased sampling frequency across Scotland that is a consequence of the statutory WFD monitoring.

In order to be able to understand these complex water body-specific responses to climate change and to be able to predict response patterns, understanding of freshwater ecosystems will be required on a case by case basis. We therefore need to continue to monitor the aquatic environment to provide information for rapid and effective management of algal incidents, and to develop novel techniques for effective monitoring and remediation of freshwaters. We also need to acknowledge that current remedial measures may need to be considerably adjusted to take into account the effects of climate change, and that current restoration techniques may become less effective due to exacerbated effects of eutrophication brought on by climate change. It may be that green is the colour of environmental acceptability, unless it refers to the colour of water bodies (Reynolds 1997).

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Effects of fertilisers on vegetation of ultrabasic terraces (1965-2010): Isle of Rum, Scotland

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ABSTRACT
An experiment was set up in 1965 on the Isle of Rum to determine the reasons for poor vegetation cover on an exposed mountain ridge. Suggested hypotheses related to effects of grazing herbivores, site exposure or soil infertility. To test one of these, a 100 m^2 experimental plot was subjected to a fertiliser regime over a period of three years with a vegetation survey and soil analysis conducted at the outset of the research period (1965), in 1969 and in 1996. Plant cover within the experimental plot increased from 5 % (1965) to 100 % (1996), and was maintained at this level in a recent monitoring (2010). A change from acidophilic plants dominated by heather to a grass/moss assemblage was also recorded within the plot over the monitoring period. Within an unfertilised control plot set up in 1996, plant cover had increased from 25 % to 50 % (2010), although there was little change in composition of plant species.
Key words: Soil nutrients, plant cover, Inner Hebrides, grazing herbivores, long-term trends, ultra-basic terraces.

INTRODUCTION
Higher plants grow where conditions permit, but some basic requirements must usually be met. A soil, or a substrate, capable of supporting root structures must be present, suitable nutrients, light and water need to be available and prolonged existence must allow for vegetative or sexual reproduction within acceptable climatic conditions. In 1965, on the Isle of Rum, Inner Hebrides, an experiment was set up to determine potential reasons for poor vegetation cover on an exposed mountain ridge (Ferreira & Wormell 1971). These authors suggested that grazing herbivores, red deer (*Cervus elaphus*) and feral goats (*Capra hircus*), site exposure (at 650 m) or the infertility of the soil (derived from ultrabasic rocks) might be causal factors. To test one of these hypotheses, a single 10 x 10m experimental plot was subjected to a fertiliser regime over a period of three years. This involved the following additions: August 1965, N (1125 kg ha^{-1}), P (500 kg ha^{-1}) and K (500 kg ha^{-1}); April 1967 and 1968, N (250 kg ha^{-1}) P (235kg h^{-1}) K (208 kg ha^{-1}) and Ca (470 kg ha^{-1}). No reason was given for the use of only one experimental plot with no control (Ferreira & Wormell 1971), however the constraints of the site in terms of altitude, remoteness and effort of transporting fertiliser to the site may well account for this.

A vegetation survey was conducted at the outset of the research period (1965) and after a period of four years (Ferreira & Wormell 1971). Thereafter, the site remained almost undisturbed until revisited in 1996 and monitored by Wilson *et al.* (1998). These authors also pegged the corners of and set up four additional plots (each 10 x 10m), close to the original (Wormell) plot. The newer plots had single applications of nitrogen, potassium or phosphorus with a control plot having no nutrient additions. Documented research on soil fauna in this location is very limited, however, Butt & Lowe (2004), sampling for earthworms on Rum, found a density of 17 individuals m^{-2} (represented by 2 epigeic earthworm species) in the Wormell fertiliser plot, compared with an adjacent (control) area which yielded no earthworms.

The current investigation, undertaken in 2009 and 2010, revisited the fertiliser plot and surrounding area to try and establish recent vegetation developments. Specific objectives were:

- To record plant cover on fertilised and control plots and compare results with previous findings;
- To sample soils and draw comparisons with previous findings;
- To use the results, with other data to predict the cause of vegetation change on the exposed experimental site.

Site Details
The Isle of Rum lies in the Inner Hebrides, 21 km off the west coast of Scotland. Since 1957, the whole island, of 10,650 ha, has been a National Natural Reserve, and is currently owned and managed by Scottish Natural Heritage (SNH). The natural and cultural history of the island is well documented (e.g. Clutton-Brock & Ball 1987; Magnusson 1997; SNH 2011) but critical details are that domestic grazing animals are restricted to a herd of Highland cattle *(Bos taurus)* and a collection of Rum ponies *(Equus caballus)* (Gordon *et al.* 1987), kept in lowland areas. A substantial population of red deer is present on Rum. Although reduced in recent years, from 1,200-1,700 of the last century (Clutton-Brook & Guiness 1987),

Payne (2003) reported approximately 1,000 animals and this level has been maintained to date. Feral goats also graze the upland areas of the island but smaller grazing mammals such as rabbits and hares are absent from Rum. However, a study between 1958 and 1970 using controlled plots on the grasslands and heaths of the island have shown that reduced grazing increases the plant litter and taller vegetation which reduces the diversity of vegetation. The management plan of the island was to maintain the high floristic diversity of all vegetation types present which led to the annual cull of red deer being severely reduced (Ball 1974).

The fertiliser plot experimental site is on the exposed Barkeval-Hallival ridge (Nat Grid Ref: NM39260 96433) comprised of peridotite and allivalite igneous ultra-basic rocks, with many exposed rocks (Ragg & Ball 1964). The thin soils formed over these base rocks have high levels of magnesium, low levels of calcium and exceptionally low levels of phosphorus; calcifuge plants often dominate here due to the low levels of calcium within the soil. There is evidence that the oceanic climate on Rum, with an annual rainfall ranging from 1,397 to 3,302 mm (Ragg & Ball 1964), is warming. The extent of snow cover and sea ice in the Northern Hemisphere has declined since 1979 (Dery & Brown 2007; Serreze *et al.* 2007) leading to increased plant growth in northern high latitudes (Myneni *et al.* 1997). On Rum, the oestrus date and parturition date in female red deer, and antler cast date, antler clean date, rut start date and rut end date in males has advanced between 5 and 12 days across a 28 year study period with the plant growth in spring and summer (growing degree days) explaining a significant amount of variation in all six of these phonological traits. (Moyes 2011).

METHODS

Fertiliser Plots

An initial survey in 2009 (26-29th April) sought to locate the plots set up by Wilson *et al.* (1998), but found that many of the metal pegs used to mark out the more recent treatments had been dislodged/removed and exact positions could not be deliniated with any confidence. Surface water was also seen to run from the location of the potassium-enhanced plot into the area where the phosphorus plot was positioned. It was therefore determined that it was unsound to survey these plots, and only work within Wilson *et al.*'s (1998) control plot and the original (Wormell) plot was undertaken. The main investigation of these two plots was undertaken in 2010 (24-28th May).

Plant Cover.

The 2009 survey of the original (Wormell) and the control plot was undertaken following the methodology described by Gilbert & Butt (2009). This made use of digital photography of vegetation within 0.5 x 05m quadrats. Although this size of quadrat was different to the original surveys (1 x 1m) the area surveyed was the same (4m^2). Images were manipulated in Adobe Photoshop (2000) to produce a 'squared' image and the percentage cover of each plant species was estimated by means of digital superimposition of a grid on to the image. In 2010 (24-28th May), a more traditional vegetation survey of both plots was conducted using a point quadrat (100 points m^{-2}) as described by Chalmers & Parker (1989). Here, only the first plant species contacted was recorded per point, to provide an estimate of mean percentage cover for each species over the whole plot. This was the same sampling technique used in earlier (1969, 1996) surveys of this area and the same area of experiment plot was sampled (4m^2).

Soil Sampling and Analyses

Soil cores (0.05 m diameter) were collected using a random sampling scheme to a depth of 0.15 m in the experimental (n=16) and control (n=16) plots, and sub-divided into samples at 0.05 m depths. Due to the shallowness of soil only eight of the control plot sample cores achieved the depth of 0.15 m in contrast to all experimental plot samples. Each soil horizon was described by reference to a Munsell soil colour chart (1992). Soil bulk density was determined after samples were air dried, sieved to <2 mm and calculated as mass of air dry soil per unit volume, corrected for stone content. Soil collection and soil analyses duplicated as closely as possible that utilised by Ferreira & Wormell (1971) and Wilson *et al* (1998). However, in the current survey nutrient content of soils was not analysed by the authors, but undertaken at an accredited laboratory (Macaulay Land Use Research Institute).

RESULTS

Plant Cover

The 2009 survey using digital photography showed the fertiliser plot to be completely vegetated, except for areas covered by a few large rocks that protruded through the plants. This showed no change since the survey of 1996. The photographic survey of the control plot showed a vegetation cover of 48 %, an increase from 25.2 % in 1996, very similar to the 2010 point quadrat survey of 50%. Table 1 shows the species list for plants found in both the fertiliser plot and the control plot, obtained from point quadrat survey in 2010. Comparative results from previous surveys are also provided in Table 1. Results from 2010 also confirmed the 2009 photographic survey results that the fertiliser plot is still 100 % vegetated, an increase from 5-10 % vegetation cover recorded prior to fertiliser addition in 1965.

Calcifuges such as *Calluna vulgaris* (L.) Hull (heather) and *Rhacomitrium lanuginosum* (Hedw.) Brid. reported in 1998, were not recorded within the fertiliser plot in the current survey. Grasses and mosses accounted for the majority of the plant cover within the plot with *Hypnum cupressiforme* (Hedw), *Rhytidiadelphus squarrosus* (Hedw.) Warnst. and *Festuca vivipara* (L.) offering most of the cover. *Anthoxanthum odoratum* (L.) and *Taraxacum officinale (Weber.)* first observed in 1996 but not recorded in the survey, accounted in 2010 for 9 % and 0.5 % of the cover respectively.

Peltigera spp was observed for the first time within the fertiliser plot during the current survey.

		Fertiliser Plot – set up in 1965				Control – set up in 1996	
		1965 DAFOR	1969 DAFOR	1996 % cover	2010 % cover	1996 % cover	2010 % cover
Agrostis capillaris L. **Common Bent**	M	f	cd (15%)	7.75	2.0	1.46 (5.9)	2.5 (5.2)
Alchemilla alpina L. **Alpine Lady's mantle**	D	-	-	•	-	-	-
Antennaria dioica (L.) Gaertn. **Mountain Everlasting**	D	o	r	•	-	0.77 (3.1)	0.5 (1.05)
Anthoxanthum odoratum L. **Sweet Vernal-grass**	M	-	-	•	8.75	-	-
Arabis petraea (L.) Lam [*Cardaminopsis petraea* (L.) Hiit]. **Northern Rock-cress**	D	r	r	•	-	-	-
Armeria maritima (Mill.) Willd. **Thrift**	D	-	-	•	0.5	-	-
Barbula rigidula (Hedw.) Mitt.	B	-	a	-	-	-	-
Calluna vulgaris (L.) Hull **Heather**	D	f	o	0.25	-	10.62 (42.1)	23.75 (49.75)
Campylopus atrovirens De Not.	B	r	-	-	-	-	-
Carex binervis Sm **Green-ribbed Sedge**	M	-	r	-	-	-	-
Carex viridula [*demissa*] Michx. **Yellow-sedge**	M	r	-	-	-	0.46 (1.8)	12.75 (26.70)
Carex panicea L. **Carnation Sedge**	M	-	-	-	-	0.23 (0.9)	
Carex pilulifera L. **Pill Sedge**	M	-	r	-	-	-	-
Cerastium fontanum (holost.) Baumg. **Common Mouse-ear**	D	-	r	0.25	1.0	0.03(0.1)	0.25 (0.52)
Cladonia uncialis (L.) Weber	B	-	-	0.25	-	0.03(0.1)	
Cynosurus cristatus L. **Crested Dog's tail**	M	-	-	-	-	-	-
Danthonia decumbens (L.) [*Sieglingia decumbens*] **Heath grass**	M	o	r	-	-	-	-
Deschampsia flexuosa (L.) Trin. **Wavy Hair-grass**	M	f	a	•	-	0.20 (0.7)	-
Dicranum scoparium Hedw.	B	-	-	3.75	-	-	-
Euphrasia sp. L. **Eyebright**	D	o	-	0.25	-	0.03 (0.1)	
Festuca rubra L. **Red Fescue**	M	-	r	•	-	-	-
Festuca vivipara (L.) Sm. **Sheep's fescue**	M	f	cd (15%)	27.75	30	1.72 (6.8)	3.0 (6.28)
Hypnum cupressiforme Hedw.	M	o	-	16.25	32	-	-
Juniperus communis alpine, Celak. **Alpine Juniper**	G	r	-	-	-	-	-
Molinia caerulea (L.) Moench. **Purple moor-grass**	M	o	-	-	-	-	-
Nardus stricta L. **Mat-grass**	M	-	-	•	0.5	0.33 (1.3)	-
Oligotrichum hercynicum (Hedw.) Lam & Cand.	B	-	o	-	-	-	-
Plantago lanceolata L.	D	-	-	•	-	-	-
Plantago maritima L.	D	f	a (5%)	3.00	-	2.15 (8.5)	2.00 (4.19)
Polygala serpyllifolia Hose. **Heath Milkwort**	D	o	-	•	-	0.03(0.1)	-
Polytrichum alpinum Hedw.	B	-	o	5.25	7.5	-	-
Polytrichum piliferum Hedw.	B	o	-	-	-	-	-
Polytrichum urnigerum Hedw.	B	-	a	-		-	-
Potentilla erecta (L.) Rausch. **Tormentil**	D	f	o	1.5	0.25	0.72 (2.9)	•
Rhacomitrium lanuginosum (Hedw.)Brid.	B	f	-	0.5	-	3.36 (13.3)	0.75 (1.57)
Rhytidiadelphus squarrosus (Hedw.) Warnst.	B	r	-	18.5	11.75	0.05 (0.2)	0.5 (1.05)
Rubus saxatilis L. **Stone Bramble**	D	o	f	0.25	-	0.08 (0.3)	-
Selaginella selaginoides (L.) Beauv. **Lesser Clubmoss**	B	r	r	•	-	0.05 (0.2)	-
Silene acaulis (L.) Jacq. **Moss Campion**	D	-	-	•	-	-	-
Solidago virgaurea L. **Goldenrod**	D	o	o	•	-	0.21 (0.9)	-
Succisa pratensis Moench **Devil's-bit Scabious**	D	o	-	-	-	-	-
Taraxacum officinale Weber.	D	-	-	•	0.5	-	-
Thymus polytrichus [*praecox* Opiz] **Wild Thyme**	D	f	f	11.75	5.25	2.13 (8.5)	1.75 (3.66)
Trichophorum cespitosum (L.) Hartm. **Deergrass**	M	-	-	-	-	0.41 (1.6)	
Vaccinium myrtillus L. **Bilberry**	D	-	-	•	•	-	-
Viola riviniana Reichb. **Common Dog-violet**	D	o	o	2.75		0.15 (0.6)	•
Peltigera spp	L	-	-	-	•	-	-
Total plant cover (%)		5 - 10	60	100	100	25.2 (100)	50.25 (100)

Table 1. Plant species recorded in the fertiliser plot and control plot at an altitude of 650 m on the Barkeval-Hallival ridge, Isle of Rum. Results from previous studies (Ferreira and Wormell 1971; Wilson et al. 1998) also provided. Figures in parentheses are percentage of total vegetation cover, • denotes species that were observed but not recorded, cd =co-dominant. (M=Monocotyledonous, B=bryophyte, D=dicotyledonous, P=pteridophyte, L=lichen, G=Gymnosperms, [ ] = former names). English names (Stace 2010).

The vegetation cover of the fertiliser plot changed considerably since 1965 and contrasts with the control plot, delineated by Wilson *et al.* (1998). Overall, vegetation cover of 50 % was recorded in the control plot, an increase from the 25 % noted in 1996, the dominant vegetation was heather with 24 % cover.

Soils

Soil profiles of the untreated (control) plots in 1965, 1996 and 2009 are very similar with approximately 0.03 m of very dark brown organic matter (10YR 2/2) above a yellowish-brown mineral horizon (10YR 5/4). This profile was not uniform across the control plot in 2009, with the organic horizon ranging from 0 - 0.1 m, due to erosion and deposition. The horizon below the fertiliser plot was very different, with a deeper organic horizon to 0.04 m (10YR 2/1) and organic staining (10YR 2/2) down to 0.08 m, above a similar yellowish-brown mineral horizon (10YR 5/4). This was deeper than records from 1996, when the organic horizon reached to a depth of 0.03 m with staining to 0.06 m. Soil bulk density within both the fertiliser plot and the control plot increased with depth, although both results recoded were generally lower than those reported by Wilson *et al.* (1996) except in the control plot at 10 – 15 cm (Fig. 1).

Fig. 2 provides results from the fertiliser plot before treatment (1965), in 1996 and 2010. Most measurements showed an increase over time of; organic matter, pH and nutrients, which generally reduced with increasing depth. The exception was phosphorus, as Wilson *et al.* (1998) previously recorded a much higher level. There was also an increase in magnesium recorded in the upper section of the soil cores (0 - 0.05 m) extracted from the fertiliser plot.

Results from the control plot, in addition to the fertiliser plot before treatment, are given in Table 2. Here, within the upper 0.05 m, there has been an increase in organic content, pH and some nutrients, although no phosphorous was recorded in 2009. A much higher level of magnesium (135 mg kg^{-1}) was also recorded.

Although comparison of nitrate content of the plots was not possible, due to different analyses undertaken, the results are presented for possible comparison in future studies. Fertiliser plot; 0 - 0.05, 0.05 - 0.10, 0.10 - 0.15 m contained 1.65, 4.78, 6.66 mg kg^{-1} respectively (n=16). The control plot contained 18.48 mg kg^{-1} at 0 - 0.05 m (n=16).

DISCUSSION

Results from the original (Wormell) plot suggest that even after 45 years the fertiliser continues to have an effect. Acidophiles within the plot continue to decline, for example, reduced cover of heather was reported by previous authors but not recorded within the current survey. A similar reduction for heather has been reported on heathland sites that have received fertiliser applications (Aerts 1993). Here on Rum, there was no evidence of an increase in heather, as previously suggested by Wilson *et al.* (1998). However, grass and moss species (*F. vivipara* and *H. cupressiforme* specifically) dominate the plot. (There is also increased pH and nutrient content of the soil.)

The ultrabasic rocks, with low plant nutrients, but high concentrations of magnesium, now appear to have little effect on the plant species in the area. However, a high recording of magnesium (675.4 mg kg^{-1}) was found in the upper (0 - 0.05 m) cores from the fertiliser plot. This may in part be wind-borne material from the surrounding unvegetated areas, or from the analysis method used. However, high concentrations of potentially toxic elements, such as magnesium, have been shown to have little effect on vegetative growth (Looney and Proctor 1990).

Vegetation cover within the control plot has increased from 25 to 50 % (1996-2010) and from (at best) 10 % in 1965. This, seemingly un-manipulated increase, may be accounted for by a number of factors. The known reduction in deer number, particularly in recent years, may be partially responsible, with less than half the number of 15 years ago, now grazing on Rum (Payne 2003). This may be particularly important at the experimental plot site, as this green square at altitude of 650m must act as an attraction to herbivores. In addition, enhanced climatic conditions (e.g. Moyes 2011; Myneni *et al.* 1997) may have led to a prolonged growth period each year.

The assumption by Wilson *et al.* (1998) that heather had influenced pH in the control plot was not confirmed in the current survey. Although cover of heather had increased (10.6 to 23.7 %), pH had also increased from 4.9 to 5.7. This may be accounted for by the increased vegetation cover reducing leaching with more minerals and nutrients held in the substrate beneath the plants.

It was unfortunate that the additional (single element) fertiliser plots set up by Wilson *et al.* (1998) were considered unfit for survey. Continued monitoring of these plots might have led to a clearer understanding of how specific nutrients affect plant growth at an altitude of 650m in an exposed environment. However, it does demonstrate that experiments of this type on an exposed mountain ridge need to be robust in their design and execution.

That earthworms are present in the fertiliser plot (Butt & Lowe, 2004) is not unexpected, as these animals require a minimum level or organic matter (as shown in Fig. 2). Such animals are not uncommon at this altitude on these rocks/soils but are usually associated with natural "greens" created through fertiliser addition from nesting bird faeces (e.g. Furness, 1991). Further research in this area is ongoing (Callaham *et al.*, in press).

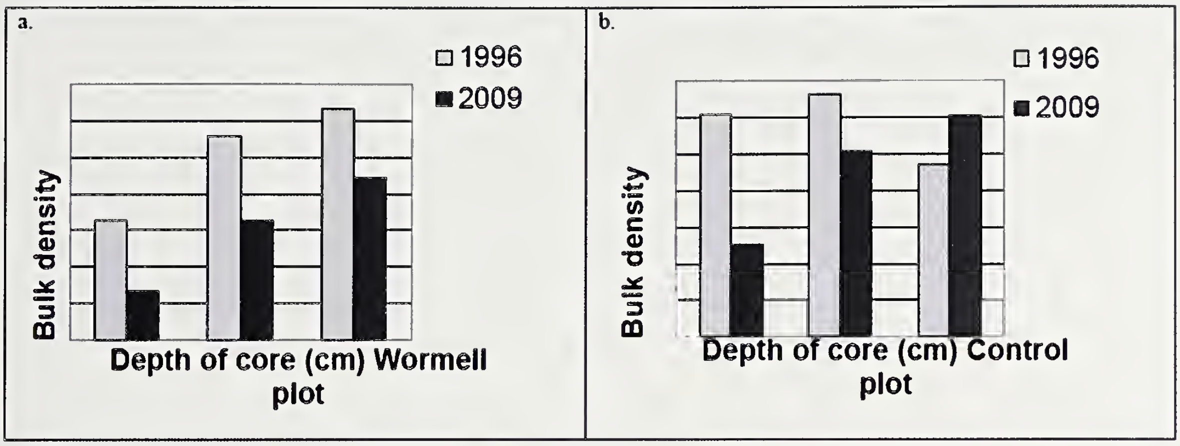

Fig. 1. Bulk density soil measurements from (a) (Wormell) fertiliser plot and (b) control plot.

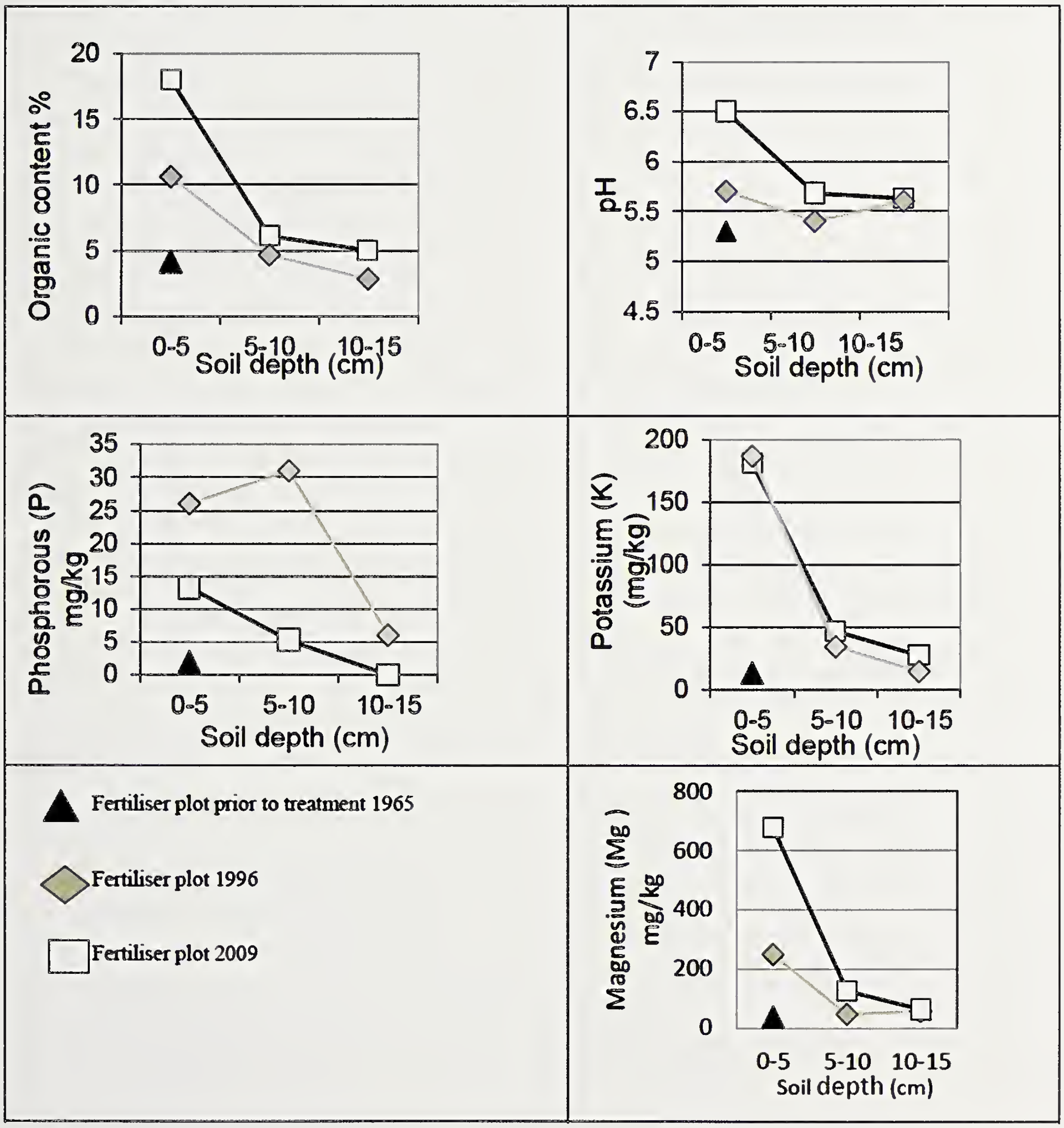

Fig. 2. Soil analyses of the (Wormell) fertiliser plot over a 45 year period.

	Organic matter content	pH	Phosphorous mg kg^{-1}	Potassium mg kg^{-1}	Magnesium mg kg^{-1}
Fertiliser plot pre treatment	4.15	5.3	2.0	13	37
Control Plot 1996	4.85	4.9	3.1	29	20
Control Plot 2009	6.4	5.7	0.0	41	135

Table 2. Soil data derived from control plots over a 45 year period, only results of the upper 5 cm of the core provided.

It is currently difficult to assess the direct influence brought about by reduced levels of grazing, and/or the increase in temperature on vegetation growth days on the fertiliser plot. Increased vegetation cover within the control plot indicates that there has been some effect, as this is not directly related to historical fertiliser addition. Further carefully designed experiments, to address Wormell's original hypotheses may still be warranted, to fully determine limiting factors associated with plant growth of patchy herb-rich *Calluna* heath/grass-dominated swards at altitude on Rum.

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Long-term dynamics in Scottish saltmarsh plant communities

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ABSTRACT
In 2011, we conducted a resurvey of saltmarsh plant communities present at six sites along the mainland coasts of Scotland, previously surveyed in 2006. Three sites located on the Isle of Mull (Inner Hebrides) that were previously studied in 1957 were also resurveyed. The data, analyzed using TWINSPAN classification and CCA ordination procedures, suggested that geographical factors were more important than time in driving the observed differences in plant community composition. For example, only at Ardmore Point (Firth of Clyde), and Aberlady and Skinflats (Firth of Forth), were there distinct pioneer zones containing *Salicornia europaea* found in 2011. All sites supported recognizable mid-marsh and upper marsh communities. Overall, this study provides evidence for some degree of stability in Scottish saltmarsh plant communities, whether over a short timescale of 5 years or a longer period of 54 years.

INTRODUCTION
Saltmarshes develop on wave-protected shorelines in temperate regions worldwide as a result of interactions between vegetation and tidal action, relative sea level rise, climatic extremes, and sediment deposition rate (Harvey and Allan 1998; Beeftink 1977). The accumulation of sediment, vegetation fragments and various other suspended materials deposited by the tide creates a mudflat, which facilitates the settlement of specialist halophytic vegetation such as *Salicornia* and *Puccinellia* spp. (Fariña et al 2009; Steers 1977). This leads to an increase in the elevation and stabilization of substrate and ultimately, to the formation of creeks, channels and other conditions favourable for plant species less tolerant of frequent tidal submergence (Steers 1977). The change in elevation gives rise to distinct patterns of vegetation, known as zones, which typically occur in belts that run parallel to the shoreline (Adam 1990).

Most established saltmarshes can be divided into three distinct vegetation zones (species given as examples here relate to UK saltmarshes, though many of the saltmarsh plants have rather broad, cosmopolitan distributions in Europe): (1) a pioneer/low marsh zone defined by soft sediments, seaweeds and a few specialist halophytes such as *Salicornia europaea* and *Puccinellia maritima,* (2) an accretion/mid marsh zone that usually displays a large variety of environmental conditions and supports common saltmarsh species such as *Festuca rubra, Juncus gerardi* and *Agrostis stolonifera*, and (3) a mature/upper marsh zone, which occurs towards the upper limit of tidal influence and contains species less tolerant to salt and regular submergence, such as *Elymus pycnanthus*.

Saltmarshes offer a plethora of ecosystem services, including biodiversity preservation, water quality improvement, flood abatement, shoreline stabilization and carbon and nutrient sequestration. They also provide valuable habitat for migratory waterfowl and young commercially important species of fish (Zedler and Kercher 2005). Since vegetation plays a crucial role in the establishment and growth of saltmarshes, monitoring the changes in the composition of plant communities over time is one way to determine whether these systems are functioning properly. Such studies can then provide an indication of any significant variation occurring and whether these changes are due to anthropogenic pressures, such as abnormal rise in sea level, invasive species or development (Gedan et al 2009).

Previous long-term studies of saltmarsh plant communities have focused on the effects of sudden and extreme changes of weather, planned technical interference, dynamics of vegetational change (Beeftink 1979) and grazing intensity (Andresen et al 1990) to identify the responses of different species to environmental disturbances. Studies of the long-term composition of saltmarsh vegetation through the use of permanent plots (accurately marked plots where vegetation releves have been sampled repeatedly over a period of time), have been undertaken at Boschplaat on the island of Terschelling in The Netherlands, where a saltmarsh began to form on a sand flat after the construction of a sand dam in the 1930s (Leendertse et al 1997; Roozen and Westhoff 1985; Smits et al 2002).

Scottish coasts contain about 15% of the UK's 44,000ha saltmarsh resource, of which the marshes in the Solway Firth account for 8% (Hansom and McGlashan 2004). Saltmarshes in Scotland occur mainly in estuaries and at the heads of sea lochs (Harvey and Allan 1998). Two previous studies of vegetation communities of various saltmarshes in

Scotland include Gillham's 1957 survey of three sea loch marshes located on the Isle of Mull in the Inner Hebrides, and Zimmerman and Murphy's 2006 survey of three sea loch and four estuarine marshes on the east, west and southern mainland coasts.

We were able to obtain the raw plant species abundance data from both studies, which made it possible to visit and resurvey these sites in 2011 in order to examine the dynamics of Scottish salt marsh plant communities over a short time scale of five years at the mainland sites, and a longer period of 54 years at the sites on the Isle of Mull. In addition to this comparison of historical and recent vegetation data, environmental variables such as soil pH, vegetation height, and soil conductivity were measured in the current study to assist in determining what factors are responsible for plant community patterns within a marsh (zonation) and between different marshes (geographical location).

METHODS

Study Sites

Nine sites from earlier studies were resurveyed (Fig. 1). Three of these were previously surveyed in 1957 by Gillham and are situated along sea lochs located on the Isle of Mull in the Inner Hebrides: Loch Guin, Loch naKeal and Loch Seridain. The other six sites were last surveyed by Zimmermann and Murphy in 2006 and included four along the west coast of mainland Scotland: Port Appin, Loch Etive and Loch Creran near Oban; and Ardmore Point in the Inner Clyde, plus two on the east coast: Aberlady Bay in the outer Firth of Forth and Skinflats, which is also located in the Forth, near Falkirk. The tenth site, Powfoulis New Lagoon, is a newly restored saltmarsh, on previously reclaimed farmland, which is located directly inland from the Skinflats site: no historic data (prior to restoration) were available for this site.

These locations were primarily chosen because data existed from previous years from which to compare possible shifts in vegetation communities over different time scales. They are also representative of the different habitats in (estuaries and sea lochs) and environmental conditions (West and East coasts; island and mainland; and lower and higher latitudes) under which saltmarshes may develop in Scotland. Zimmerman and Murphy (2007) also sampled a site in the Solway Firth (River Cree), but we were unable gain access to the site late in the season, at the time of the fieldwork for this study.

Survey Methods

Surveys of the ten sites were done late September through mid-November 2011. At each site, samples from three randomly located replicate stations were collected from each of three sub-sites corresponding with the three distinct vegetation zones: pioneer/low marsh, accretion/mid marsh and mature/high marsh. One GPS reading was taken (using a Garmin Etrex instrument) to accurately geolocate every sub-site.

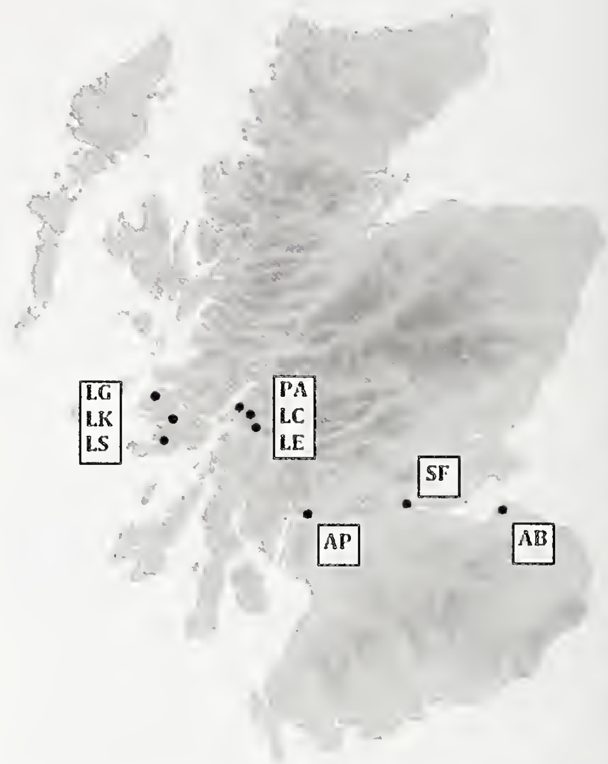

Fig. 1. 2011 Survey site locations. AB = Aberlady Bay, AP = Ardmore Point, LC = Loch Creran, LE = Loch Etive, LG = Loch Guin, LK = Loch naKeal, LS = Loch Scridian, PA = Port Appin; SF = Skinflats (Powfoulis New Lagoon, PNL, also exists at Skinflats, as a newly-created saltmarsh site behind the seawall).

Plant species abundance was quantified by using a 0.5m x 0.5m quadrat subdivided into twenty-five 0.1m x 0.1m squares and scoring how many of the twenty-five squares within the quadrat were occupied by each species. Vegetation height was recorded at three randomly chosen points in each quadrat. Plant community diversity was recorded simply as total number of species present per sample. A soil sample was taken from each quadrat to measure pH and conductivity levels. The pH level was recorded in the field using a Hanna pH EP4 meter while conductivity was determined back at the University with a Jenway 4071 conductivity meter. Grazing pressure and environmental disturbance were scored on a scale of one to three with one corresponding to areas with a minimal amount of disturbance and three to more heavily impacted sites. In total, 99 samples were collected from the ten sites.

Data Analysis

Species abundance scores from the 2011 survey were converted by simple multiplication into percentages (%A). The multivariate classification procedure Two-Way Indicator Species Analysis (TWINSPAN: Hill and Šmilauer, 2005) was then utilized in order to group together the samples in the 2011 dataset that had similar assemblages of species. A second TWINSPAN analysis was done on the complete dataset (1957, 2006 and 2011 data) to compare and contrast past and present species assemblages. In order to make the year

datasets comparable, modifications of the raw data were required. Raw data scores from the 2006 survey were averaged and multiplied by four in order to convert the values to %A values. Data were extracted from the 1957 paper by determining percentage abundance of each species present from individual sections along the detailed transect diagrams given in the article.

Prior to performing statistical tests in Minitab (version 15), the raw 2011 environmental data set was tested for normality by performing Ryan-Joiner tests and certain variables were then $\log_e$ transformed, where necessary, in order to normalize the data. One-way analysis of variance and Tukey's mean comparison tests were used to determine whether there were any significant differences in mean values for soil pH, conductivity, vegetation height and plant species diversity, between the groups designated by TWINSPAN.

Ordination of the 2011 vegetation and environmental data was done using Canonical Correspondence Analysis (CCA, utilizing CANOCO: ter Braak and Šmilauer, 1998). CCA is a multivariate procedure, which can be used to identify patterns of plant species distribution in the context of the environmental variables measured. A Monte Carlo test was used to determine whether the variation explained by the CCA results was significant, across the first (major) axis, or all axes combined for the ordination. Plant assemblages for each zone at each site were allocated to National Vegetation Classification (NVC) saltmarsh/maritime communities using the program TABLEFIT (Hill, 1996).

RESULTS

In total, 37 species were observed in the 2011 resurvey. The five most common species were *Puccinellia maritima, Glaux maritima, Triglochin maritima, Festuca rubra* and *Juncus gerardi.*

TWINSPAN initially divided the 99 sample stations from 2011 into a large group (n=81) and a smaller group (n=18) with an eigenvalue of 0.514. At the next level, both groups were further divided into two groups each to create four groups in total (Group A: n=13 and Group B: n=68; eigenvalue = 0.474 and Group C: n=11 and Group D: n=7; eigenvalue = 0.770). Analysis stopped by the third division because eigenvalues became weaker (0.388 or less), suggesting substantial overlap between species composition of sample-groups at this point. ANOVA analyses confirmed that there were significant differences between the four TWINSPAN groups for mean soil pH ($P < 0.027$), mean soil conductivity ($P = 0.000$) and mean vegetation height ($P = 0.000$). There was no significant difference in mean species diversity among the groups (Table 1).

Group A was made up entirely of sample stations located in the pioneer zones of Aberlady, Skinflats and Ardmore Point. The indicator species listed were *S. europaea* and *Cladophora* spp. This group had the highest mean conductivity and the shortest mean vegetation height.

Group B was the largest one classified by TWINSPAN containing more than half of the total sample stations. This group contains data from all survey locations and is composed primarily of mid-marsh sites with pioneer and high marsh sites that did not display distinct high marsh (Groups C and D) or pioneer marsh (Group A) species. The indicators were *G. maritima*, *F. rubra*, and *J. gerardi* and mean conductivity, pH levels and vegetation height values were intermediate compared to values for the other three groups.

Variable	TWINSPAN sample groups								P_{ANOVA}
	A		B		C		D		
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	
Soil pH	7.16	0.18	6.91	0.07	6.86	0.15	7.54	0.26	$P < 0.027$*
$\log_e$ mean soil conductivity (μS/cm)	8.76	0.12	7.66	0.10	7.90	0.17	6.69	0.29	$P = 0.000$***
$\log_e$ mean vegetation height (cm)	1.91	0.17	2.04	0.08	3.35	0.18	2.43	0.28	$P = 0.000$***

Table 1. Mean values (±1 standard error) of statistically significant environmental variables compared between the 2011 TWINSPAN groups. For group A, n = 13; B, n = 68; C, n = 11; and D, n = 7. Stars next to P-values reflect different levels of significance (* = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$).

Groups C and D consist exclusively of high marsh zone sample stations. Group C included data from Ardmore Point and Powfoulis New Lagoon (by Skinflats). *E. pycnanthus* was the indicator species and this group had the highest mean vegetation height but the lowest mean soil pH. Samples from Port Appin, Loch Creran, Loch Scridain and Loch Na Keal comprised Group D. Group D's indicator species were *Cochlearia officinalis* and *Agrostis Stolonifera*. The average conductivity for this group was the lowest, but the average sediment pH was the highest.

The CCA ordination of the 2011 survey data, constrained by environmental variables (Fig. 2), suggests that several of the environmental factors measured are good predictors of saltmarsh plant community composition for the sites surveyed (Monte Carlo test for axis 1: $P < 0.002$, all axes: $P < 0.002$). Mean vegetation height, mean soil conductivity, longitude and latitude proved to be the significant environmental variables in predicting saltmarsh plant community distribution while factors such as soil pH, environmental disturbance and grazing pressure were less important. The overlay of the TWINSPAN groups from the 2011 data shows a strong association between high mean soil conductivity and Group A and between mean vegetation height and Group C. Groups B and D were not associated with any environmental variable in particular. The location of Group B was not displayed on the ordination graph because it consisted of sampling stations that were ubiquitously distributed across the plot.

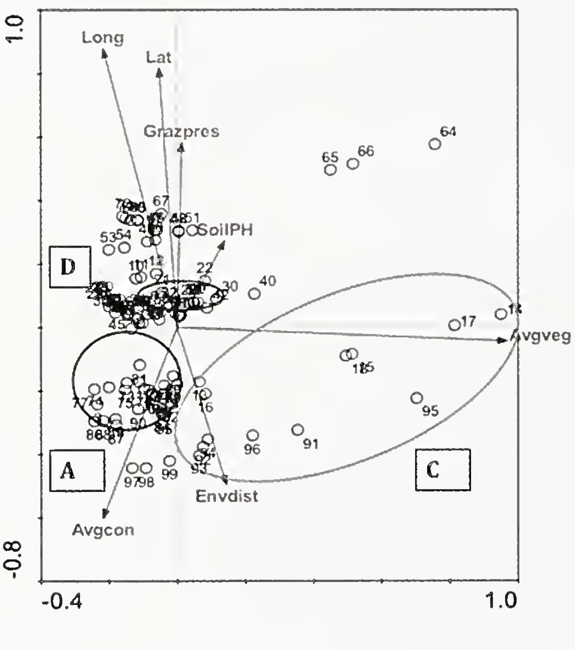

Fig. 2. Canonical Correspondence Analysis sample ordination for the 2011 survey data. Approximate location on the plot of samples making up three individual TWINSPAN sample groups is indicated for groups A, C and D. The fourth group (B) had a more scattered distribution of component samples across the ordination plot. Lat = latitude; Long = longitude; Grazpres = grazing pressure score; SoilPH = mean soil pH; Avgcon = mean soil conductivity; Avgveg = mean vegetation height; Envdist = environmental disturbance score.

Table 2 displays the 12 NVC community and sub-community types assigned to the 30 sub-sites sampled in 2011. The goodness of fit for the NVC communities allocated to the sub-sites ranged widely, from 96% and 94% for pioneer/low marsh sub-sites at Powfoulis New Lagoon and Skinflats, to 49% and 50% for mature/high marsh sub-sites at Powfoulis New Lagoon and Ardmore Point.

Another four TWINSPAN groups emerged from the comparison of the historical and current vegetation data:

Group A was composed of samples collected in 2011 only and contains data from Ardmore Point, Port Appin, Loch Creran, Loch na Keal, Loch Scridain, Aberlady Bay, Skinflats and Powfoulis New Lagoon. Species indicators included *Phalaris arundinacea, F. rubra, C. offinalis* and *E. pycnanthus*.

Group B consisted of samples collected from all three years and was the largest group defined. At least one sample from every site from the 2011 survey was represented except for Powfoulis New Lagoon. The majority of the samples taken during the 2006 survey were allocated to this group with sub-sites from Ardmore Point, Port Appin, Loch Creran, Loch Etive, Aberlady Bay and Skinflats. All the data points extracted from the 1957 survey were also included (samples from Loch Guin and Loch Scridain). The species indicators were *J. gerardi, Plantago maritima, G. maritima* and *Armeria maritima*.

Group C was the smallest and the majority of the samples were from the 2011 survey at Powfoulis New Lagoon, with one sample each from Aberlady Bay, Loch Creran and Skinflats. The rest of the samples were from the 2006 survey and were located at Ardmore Point. The indicator species were *Aster tripolium, A. maritima, Plantago maritima* and *Spergularia maritima*.

Group D very closely resembled Group A from the 2011 TWINSPAN analysis containing sub-sites from Ardmore Point, Aberlady Bay, Skinflats and Powfoulis New Lagoon with additional samples from the 2011 survey of Loch na Keal and a sample from Aberlady Bay that was from 2006. The indicator was *Cladophora* spp.

Sub-site	NVC Community	NVC Community	NVC Code	Goodness of Fit (%)
AP 1	*Puccinellia maritima* saltmarsh	None	SM 13	80
AP 2	*Festuca rubra* saltmarsh - *Juncus gerardi*	*Juncus gerardi*	SM 16b	86
AP 3	*Juncus maritimus* saltmarsh	None	SM 18	49
PA 1	*Festuca rubra* saltmarsh - *Juncus gerardi*	*Festuca rubra*	SM 16d	71
PA 2	*Festuca rubra* saltmarsh - *Juncus gerardi*	*Juncus gerardi*	SM 16b	85
PA 3	*Pucinellia maritima* saltmarsh	*Glaux maritima*	SM 13b	84
LC 1	*Festuca rubra* - *Armeria maritima* maritime grassland	Typical	MC 8a	67
LC 2	*Festuca rubra* saltmarsh - *Juncus gerardi*	None	SM 16	67
LC 3	*Puccinellia maritima* saltmarsh	None	SM 13	84
LE 1	*Festuca rubra* saltmarsh - *Juncus gerardii*	None	SM 16	97
LE 2	*Puccinellia maritima* saltmarsh	None	SM 13	77
LE 3	*Pucinellia maritima* saltmarsh	*Glaux maritima*	SM 13b	51
LG 1	*Festuca rubra* saltmarsh - *Juncus gerardi*	*Puccinellia maritima*	SM 16a	87
LG 2	*Festuca rubra* saltmarsh - *Juncus gerardi*	None	SM 16	79
LG 3	*Festuca rubra* saltmarsh - *Juncus gerardi*	None	SM 16	69
LK 1	*Festuca rubra* saltmarsh - *Juncus gerardi*	*Leontodon autumnalis*	SM 16e	70
LK 2	*Festuca rubra* saltmarsh - *Juncus gerardi*	None	SM 16	83
LK 3	*Festuca rubra* saltmarsh - *Juncus gerardi*	*Puccinellia maritima*	SM 16a	83
LS 1	*Juncus maritimus* - *Triglochin maritima* saltmarsh	None	SM 15	68
LS 2	*Puccinellia maritima* saltmarsh	None	SM 13	79
LS 3	*Pucinellia maritima* saltmarsh	*Glaux maritima*	SM 13b	78
AB 1	Annual *Salicornia* saltmarsh	None	SM 8	94
AB 2	*Festuca rubra* saltmarsh - *Juncus gerardi*	*Puccinellia maritima*	SM 16a	79
AB 3	*Festuca rubra* saltmarsh - *Juncus gerardii*	*Juncus gerardii*	SM 16b	82
SF 1	*Festuca rubra* saltmarsh - *Juncus gerardii*	*Festuca rubra*	SM 16d	63
SF 2	*Puccinellia maritima* saltmarsh	*Limonium vulgare* - *Armeria maritima*	SM 13c	71
SF 3	*Puccinellia maritima* saltmarsh	None	SM 13	94
PNL 1	*Elymus pycnanthus* saltmarsh	None	SM 24	50
PNL 2	*Spergularia marina* - *Puccinellia distans* saltmarsh	None	SM 23	84
PNL 3	*Puccinellia maritima* saltmarsh	None	SM 13	96

Table 2. National Vegetation Classification (NVC) community designations for sub-sites surveyed in 2011. For site codes see caption to Fig. 1

DISCUSSION

In 2011, a classic zoned plant community was present at every site, but there were differences in the precise composition of the vegetation communities between different sites.

Ardmore Point, Aberlady Bay and Skinflats were grouped together by TWINSPAN as being the only sites with pioneer zones colonized by *S. europaea*. This group has the highest average mean conductivity and the shortest average mean vegetation height, which is reflected in the CCA analysis because its sample stations are placed among those most positively associated with high mean conductivity and those most negatively associated with mean vegetation height. Salt water contains a high concentration of ions and halophytes such as *S. europaea* and *Puccinellia maritima* achieve tolerance of high salinity at the expense of growth (Adam 1990).

The largest TWINSPAN group contained representatives from all sites and zone types. The indicators were *G. maritima*, *F. rubra*, and *J. gerardi*, which are species characteristic of the mid-marsh zone (Rodwell 2000). The sample stations were widely distributed about the CCA ordination plot, suggesting that this group tolerates a large range of environmental conditions. None of the NVC low-marsh designations were typical of Loch Guin or Loch naKeal, but a *Puccinellia maritima* sub-community was still assigned indicating a presence of low marsh species. Since Loch Guin and Loch naKeal are island sea lochs that are very rocky and receive a large amount of rain compared to the other areas surveyed, this may have caused a more uniform plant community distribution.

High marsh sample sites from Ardmore Point and Powfoulis New Lagoon were associated with *E. pycnanthus* and *Juncus maritimus* dominant communities - both typical of upper marshes with soils of high organic content. A fenced grazing area for livestock (horses) backs the Ardmore Point marsh, so runoff from this area may result in nutrient enriched soils. Since Powfoulis New Lagoon used to be an agricultural field separated from the site at Skinflats by a seawall, it is also appropriate that it would be characterized by a *S. maritima* dominated community, which commonly occurs on or behind seawalls and generally in areas of disturbed soil and variable salinity (Rodwell 2000). This TWINSPAN group had an intermediate mean conductivity and the highest average vegetation height, which is probably due to the estuarine nature of the sites and the relatively high nutrient runoff from farmland and urban centres.

The Port Appin, Loch Creran, Loch na Keal and Loch Scridain upper marsh sites that comprise group D differ from those in group C (Ardmore Point and Powfoulis New Lagoon) almost certainly since they are all located within sea lochs. These sites collectively had the lowest average conductivity - mainly because of fresh water influence from inland rivers (the conductivity of fresh water being much less than sea water).

Puccinellia maritima, F. rubra, J. gerardi, G. maritima and *T. maritimum* were the five commonest species observed in 2011. Four out of five of these species were the same as those from the 2006 survey. The one exception was that *Plantago maritima* was much more abundant than *Puccinellia maritima* in 2006. *Plantago maritima* was also one of the commonest species found during the 1957 survey of the Isle of Mull sites. However, this species was only present in the upper marsh of Loch naKeal in the 2011 survey.

The general absence of *Plantago maritima* from the 2011 survey is most likely because it is a herbaceous perennial plant, which blooms in the spring and summer months and dies back to the rootstock in autumn. The sampling for the 2011 survey was done in autumn, while sampling in 1957 and 2006 occurred during the spring and summer months.

The shift in dominance from *Plantago maritima* to *Puccinellia maritima* might also signify retrogressive succession to an earlier successional stage, which usually occurs as a result of a decrease in marsh elevation and increase in sea level rise (Warren and Niering 1993). Leendertse et al (1997) observed a change in species dominance from *Puccinellia maritima* in 1957 to *Plantago maritima* between 1967-1990 in three mid marsh plots during their study. Increases in elevation and silt thickness coupled with a decrease in the number of floodings per year were cited as the causes. This suggests that if elevation and silt thickness were to decrease while the number of floodings per year increased, the plant community dominance might regress from *Plantago maritima* to *Puccinellia maritima*. This could perhaps contribute to the relative the lack of *Plantago maritima* observed in 2011 - especially considering the absence of *Puccinellia maritima* from Loch Scridain in 1957 and its abundance of it in 2011. However, historical measurements of elevation and flooding frequency at these sites are unavailable to allow further examination of this point.

Another change we noticed was the appearance of a *S. europaea* dominated pioneer zone at Skinflats in 2011 that was absent in 2006. The site at Skinflats was backed by a sea wall separating it from an agricultural field (historically reclaimed salt marsh) up until recently. By the time the present survey was conducted, the Royal Society for the Protection of Birds (RSPB) had introduced a regulated tidal exchange scheme between the field and the survey site. This action is part of a salt marsh restoration programme with the purpose of creating more migratory waterfowl habitat and preventing further erosion of the area. Since the hydrology of the site was altered as a result of this endeavour, this could account for a change in the intensity of the wave action, possibly generating conditions along the shoreline

more conducive to the establishment of *S. europaea* seedlings.

In addition to these differences, *Elymus. pycnanthus,* a species not commonly observed north of the Solway Firth, was present at four of the sites surveyed in 2011: Powfoulis New Lagoon, Ardmore Point, Loch Scridain and Port Appin. The species had been observed at the Ardmore Point and Loch Scridain sites in previous years, however, its presence at the Port Appin site had not been recorded before, to our knowledge. Reasons for the difference in distribution of this species could include climate change, seed dispersal through vectors such as birds, wave or wind action or both, as seed distributing animals such as birds may alter their distributions to cope with climate change (Walther et al. 2002; Howe and Smallwood 1984). At the new Powfoulis New Lagoon site, the presence of *E.pycnanthus* could also be due to the introduction of a seed mix (normally used to re-vegetate sand dunes) by RSPB there in order to help vegetate the newly constructed lagoon banks, which would be likely to include seed of *E. pycnanthus* (N. Chambers, RSPB, pers. comm.).

TWINSPAN classification of the past and present vegetation data generated four groups, three of which contain data from more than one year. One group in particular (Group B) contained 55% of the sample sites from 2011, 100% of the samples from 1957 and 91% from 2006 (Fig. 3). When comparing the plant species present at each site in 2011 to those species existing there in the previous survey, 25 - 64% of the species were the same. Since conditions in the saltmarsh ecosystem can fluctuate dramatically, the fact that the sites retained about 45% of the plant species, on average, that were observed during previous surveys provides evidence for some degree of vegetation community stability over time, whether over a short timescale of 5 years (mainland sites), or a longer period of 54 years (Isle of Mull sites).

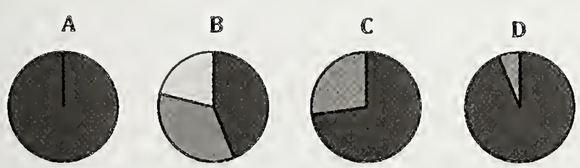

Fig. 3. Composition of the TWINSPAN sample groups (A-D) produced by classification of vegetation data from all three surveys by year (Black = 2011, Grey = 2006 and White = 1957)

Resistance and resilience to perturbations are strong influences on ecosystem stability (Tilman and Downing 1994). Long-term stability of saltmarshes is regulated by interactions between factors such as tidal inundation, land elevation, primary production and sediment accretion (Morris et al 2002). Sea level rise, invasive species and development are major threats to saltmarsh stability (Gedan et al 2009). If the level of the sea rises at a faster rate than the salt marsh can accumulate sediment and increase its elevation, then the marsh will be completely submerged, leaving behind mudflats or open water (Leendertse et al 1997). Invasions of non-native species and development of the coast can exacerbate this condition by leading to severe disruptions in salt marsh plant communities, causing the marsh to erode (Gedan et al 2009).

For future studies of long-term change in Scottish salt marsh plant communities, it would be useful to monitor additional variables such as sediment type, land elevation, sediment accretion, biomass and tidal height and frequency, in addition to those looked at in this survey. This way, if there is a very prominent change in the abundance of a certain species, such as the development of a *S. europaea* dominated pioneer zone, we can make inferences based on these measurements and observations as to whether anthropogenically-induced threats to salt marsh existence and functioning (such as sea level rise, development and invasive species) are the cause or whether natural change in the species dynamics of salt marsh ecosystems are of greater importance in explaining and predicting such vegetation changes.

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SHORT NOTES

Interesting Aculeate records from Glasgow, including eight new species records for Lanarkshire, with reflections on their wider distribution in Southern Scotland

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INTRODUCTION

With the exception of the bumblebees, there has been a general lack of recording for the aculeates in south west Scotland, least of all in urban areas such as Glasgow. They are a fascinating but intimidating group for the uninitiated. They can be challenging to identify and user friendly taxonomic guides are not readily available; consequently general naturalists tend to shy away from them when compiling their biological records. Published articles and our museum collections reveal more active aculeate recording during the early part of the 20th century (see results), coinciding with the publication of identification keys, which often help generate an interest. There are a few members of the Bees, Wasps and Ants Recording Society (BWARS) that have been actively recording in Scotland recently, but there is still much to do to address the gaps in our knowledge of the current species distribution. This paper presents interesting records resulting from fieldwork in Glasgow and from specimens submitted for identification in 2009. In addition to this, earlier local records have arisen from the identification of undetermined museum specimens. The 2009 records include six species that have not previously been recorded from Lanarkshire (VC77) and two species which were thought to be new but turn out to have been active here longer than expected. Historical records compiled from museum collections and publications are also presented; these records provide a valuable insight into the wider and historical distribution of these species in Scotland in relation to our recent findings.

The principal Scottish aculeate collectors whose records and specimens were examined to produce this article include John Russell Malloch and Andrew Adie Dalglish, who collected and documented the aculeates for *The Fauna and Flora of the Clyde Area* (Elliott et al. 1901) and deposited many specimens with the Glasgow Museums (GM). James Joseph Francis Xavier King, whose prolific collecting between 1877 and 1930 has yielded useful information on species distributions and abundance throughout Scotland, and provided a substantial reference collection for researchers. King's collection is housed at the University of Glasgow's Hunterian Museum (HM). William Evans (Evans 1900, 1901), who recorded and published his findings about the aculeates in the Lothians, Clyde and beyond, T. M. McGregor (McGregor, 1893) for those of Perthshire, James Clark (Clark, 1909) who, with the assistance of Henry Thomas did the same for Ayrshire and Arran and A. B. Duncan, a contemporary collector, who recorded in many parts of Scotland in the 1970s and 80s; all of whom have speeimens deposited at the National Museum of Scotland (NMS).

METHODS

Fieldwork was under taken by the authors during warm sunny days between April and the end of July 2009, which ensured that insects were active. Specimens were collected by sweep netting individuals on the wing or targeting nesting sites in the case of species nesting in aggregations. Other specimens were collected directly into a pot whilst foraging on flowers or at rest on the ground.

Specimens were identified using Else (in prep) and the *Nomada* test key (Stubbs, 2007). The voucher specimens from the fieldwork and identifications for 2009 are housed with either Glasgow Museums (GM) or the Hunterian Museum (HM), Glasgow. Previously unidentified specimens housed at the GM were identified by Cathy Fiedler as part of her Natural Talent Hymenopterist apprenticeship with the British Trust for Conservation Volunteers (BTCV).

Recent species distributions were checked online using the BWARS database, via the NBN Gateway (BWARS, 2010 and NBN, 2010) and the Scottish Aculeates List (SAL, 2010). The Glasgow Species Audit list 2009 (GSA, 2009) was also examined. The audit is kept by the Local Records Centre at GM and details published and submitted floral and faunal records dating from 1801. Published records from across Scotland were identified on the Scottish Invertebrates Reeords Index (SIRI), which is housed at the NMS. The collections of the GM, HM and NMS were inspected for specimens from Glasgow and the

surrounding areas. Where Scottish records were numerous for a species on the NBN or in the museum collections, only key records are included in the results data, which are generally those from south west Scotland

The species records that resulted from this study have been passed on to BWARS for incorporation in their national recording scheme and to the compiler of the Scottish Aculeates List for information.

RESULTS

Results below are from museum collections and publications. Collections are referenced if data was collected directly from a specimen – the name of the collection the specimens are housed at are given in brackets i.e. (GM), (HM) or (NMS). Publications are referenced as standard and (NBN) indicates data was from the NBN database.

Andrena clarkella

Renfrewshire, Giffnock, collected by J. R. Malloch pre 1901 (Elliot et al. 1901); Ayrshire, Craufurdland, Dalrymple, Ness Glen nr. Dalmellington, collected by J. Clark, 1907-1909 (Clark, 1909), Irvine, collected by A. Dalglish, pre 1901 (Elliot et al, 1901), Clyde Islands, Arran, Lamlash, collected by J. Clark, 1908 and Brodick, collected by W. Evans, pre 1909 (Clark, 1909); West Lothian, Drumshoreland, collected by W. Evans, 1902 (NMS); Midlothian, Inveresk, collected by W. Evans, 1901 (NMS) and Balerno, various collectors, 1900-1938 (NMS); Dunbartonshire, Murroch Glen, collected by J.R. Malloch pre 1901 (GM); Stirlingshire, Callander, collected by W. Evans 1900 and 1902 (NMS); West Perthshire, Dollar, collected by W. Evans, 1897, (NMS); Dumfries and Galloway, Castlehill, collected by A.B. Duncan, 1974 (NMS); Wigtonshire, Southerness and Torrs, collected by A.B. Duncan, 1981-1983 (NMS).

Bombus sylvestris

Midlothian, 2006 (NBN), Balerno, Anon, 1922 (NMS); Mid/West Lothian, 2008 (NBN); Dunbartonshire, Bonhill, collected by J.R. Malloch, c1900 (GM); Ayshire, 1995 and 2008 (NBN), Dreghorn, Anon., 1923 (NMS); Wigtonshire, 2005, and Wigtonshire/Kirkcudbrightshire, 1987 (NBN); Dumfriesshire, 1975 (NBN), Newlands, collected by A. B. Duncan, 1929 (NMS); near Kirn in Argyll, K. M. Guichard, 1939 (Guichard, 1940) and more widely across Scotland including Inverness-shire (NMS) Fladday (Guichard, 1940) and Morayshire (HM).

Colletes daviesanus

Lanarkshire, Glasgow, Kelvingrove Park collected by F.R. Woodward, 4th July 1984 (GM); Midlothian, Musselburgh, collected by W. Evans, 1900 (NMS); Dumfriesshire (SIRI/NBN); and more widely across Scotland including Fife (NMS), Perthshire (McGregor, 1893), Morayshire (HM) and supposedly the Hebrides (SIRI). The Hebrides specimen is however likely to be a misidentification of *C. floralis*.

Lasioglossum calceatum

Lanarkshire, Glasgow, Glasgow Botanic Gardens, 12th August 1984 and Kelvingrove Park, 8th August 1983, collected by R. Sutcliffe, (GM); Renfrewshire, Kilbarchan, F.J. Ramsay, 1944 (NMS); Ayrshire, Clyde Islands, Arran, Anon., 1900 (NMS); Dunbartonshire, Loch Lomond, collected by R. Sutcliffe, 26th May 1986 (GM), Bonhill, collected by J.R. Malloch, 1901 and Anon., 1900 (GM and NMS respectively); common in the south of Dumfriesshire in May and Autumn circa 1940 (Murray, 1940), and more widely distributed records include Perthshire (GM), Aberdeenshire (HM), Kincardineshire (HM), Morayshire (HM).

Lasioglossum fratellum

Stirlingshire, Mugdock Wood, collected by J. Cooter, 1976 (GM); Renfrewshire, Kilbarchan, collected by F.J. Ramsay, 1944 and 1947 (NMS); Ayrshire, Irvine Moor, Anon., 1900 (NMS), Arran, collected by Waterston, 1936 and 1937 (NMS) and Corrie, 1939, K. M. Guichard (Guichard, 1940); Bute, Rothesay, Anon., 1901 (NMS); East Lothian, Longniddry, Anon., 1895-1898 (NMS) and Aberlady, collected by W. Evans, 1895 and 1896 (NMS); Dunbartonshire, Bonhill, collected by J.R.Malloch, 1901 (GM); Argyll, Alt Broiglechan, Anon., 1988 (GM) and Glen Nant, collected by J. Cooter, 1978 (GM); and more widely across Scotland including Perthshire (NMS), Invernesshire (HM, NMS, Guichard, 1940), Colonsay (NMS), Aberdeenshire (HM), Morayshire (HM), and possibly Sutherland (HM).

Lasioglossum smeathmanellum

Ayrshire, Shewalton Pits, collected by J. Robinson, 2009 (GM), Arran, Brodick, 1909 (Clark, 1909), Kilmarnock, collected by J. Clark, 1908 (Clark, 1909), the Dean and Fenwick 1907-1909 (Clark 1909), Ness Glen nr Dalmellington, 1909 (Clark, 1909); Midlothian, 1995 (NBN); East Lothian, Haddington 1996 (NBN); Dunbartonshire, Bonhill and Cardross, collected by J.R. Malloch, 1901 (GM), Elliot et al., 1901); Dumfriesshire, nr Gretna, J. Murray, circa 1940 (Murray, 1940) and more widely across Scotland including Perthshire (McGregor 1893, Carter 1901, Rothney 1906), North budes (SIRI), Morayshire (HM).

Megachile willughbiella

Renfrewshire, Darnley, Waulkmill Glen collected by E. G. Hancock, 1993 (GM/Hancock, 1994); Ayrshire, Craufurdland, 1908, (Clark, 1909) nr Kirk Alloway, 1907-1909 (Clark, 1909), Ness Glen, 1907-1909 (Clark, 1909), Kilkerran, collected by Henry Thomas, 1908 (Clark, 1909), and Barr, collected by A. Dalglish, pre 1901 (Clark, 1909); Dumfries and Galloway, Rockcliffe, collected by R.A. Crowson, 1966 (HM), Caerlaverock, collected by A. B. Duncan, 1984 (NMS), nr Dumfries, R. Service, 1879 (Service, 1879); East Lothian, Dunbar, collected by W. Evans, 1893 –1900 (Evans, 1901), and more widely across Scotland including Fife (NMS) and Kirkcudbrightshire(NMS).

Nomada marshamella
Moss, collected by R. Service, 1879 (Service, 1879) South Dumfriesshire, J. Murray circa 1940 (Murray, 1940); Stirlingshire/West Perthshire (1983); Argyllshire, 1988 (NBN), Kintyre, Tayvallich, 1988 (NBN) and more Renfrewshire, Kilbarchan, collected by F.J. Ramsay, 1944 and 1946 (NMS); Dunbartonshire, Gartlea, 1985 (NBN), Bonhill, collected by J.R. Malloch, 1901 (GM) and Milton on Campsie, collected by J. Cooter, 1977 (GM); Dumfries and Galloway, Dalskairth and Lochar widely across Scotland including Perthshire (McGregor, 1893), North (SIRI) and South Ebudes (NBN).

Species	County	Location	Date	Collected by	Determined by	Specimen held
Andrena clarkella	Lanarkshire	Glasgow, Bunhouse Road, NS563663	01/04/2009	E.G. Hancock	C. Fiedler	HM
Bombus sylvestris	Lanarkshire	Glasgow, Provan Hall, NS669664	30/05/2009	J. Robinson	J. Robinson	GM
Colletes daviesanus	Lanarkshire	Glasgow, Binghams pond, NS554681	05/07/2009	J. Robinson	J. Robinson	GM
	Lanarkshire	Glasgow, Binghams pond, NS554681	26/07/2009	R. Weddle	C. Fiedler	HM
	Lanarkshire	Necropolis, NS605654	07/07/2009	R. Weddle	C. Fiedler	HM
Lasioglossum calceatum	Lanarkshire	Glasgow, Commonhead Moss, NS697659	29/05/2009	J. Robinson	J. Robinson	GM
Lasioglossum fratellum	Lanarkshire	Glasgow, Commonhead Moss, NS697659	29/05/2009	J. Robinson	J. Robinson	GM
Lasioglossum smeathmanellum	Lanarkshire	Glasgow, NS599651	10/05/2009	R. Weddle	C. Fiedler	HM
Megachile willughbiella	Lanarkshire	Glasgow, Binghams Pond, NS554681	5/07/2009	J. Robinson	J. Robinson	GM
Nomada marshamella	Lanarkshire	Glasgow, Hayburn Lane, NS556676	24/5/2009	R. Weddle	C. Fiedlier	HM
Nomada marshamella	Lanarkshire	Glasgow, Provan Hall, NS669664, on garden wall by Andrena scotica nests	30/05/2009	J. Robinson	J. Robinson	GM

Table 1. Aculeate specimens collected in Lanarkshire during 2009 fieldwork.

DISCUSSION
Western Scotland experienced mixed fortunes weather-wise during the summer of 2009, with 60% more rain than normal but warmer temperatures than either 2008 or 2007 (Met Office, 2009). On a number of days, we were met with ideal field conditions for surveying aculeates, of especially warm and dry weather.

Initial searches on the BWARS database, Scottish Aculeates List and Glasgow Species Audit led us to believe that many of our finds were new records for Glasgow and possibly the wider area. Inspection of the three museum collections and historical documents revealed that much work has been carried out on aculeates in Scotland during the 20th century, but is not widely known about or cited. Indeed, many species that appeared of particular note were recorded previously, up to a century ago. These new records contribute to our knowledge of the species' distribution over time, and reassuringly for aculeate conservation, reveals that some populations may have persisted in the south of Scotland for over a century. *A. clarkella*, *B. sylvestris*, *L. fratellum*, *L. smeathmanellum*, *M. willughbiella* and *N. marshamella* have not previously been recorded from Lanarkshire. *C. daviesanus* and *L. calceatum* were thought to be new but turn out to have been here longer than expected.

Male and female solitary bees of the attractive, tawny-thoraxed *A. clarkella* were active at the start of April. They had excavated burrows beneath the scrubby borders of one the West End's car parks, adjacent to the river Kelvin. All the Scottish records, we examined, are from between early March and April. Their season in Scotland is February and May. They are oligolectic on *Salix*, hence the early season (Pers. Comm. Murdo Macdonald. October 2011). Although a new record for Lanarkshire, historically, *A. clarkella*

appears widespread in southwest Scotland. It has certainly been recorded from the majority of vice counties that border Lanarkshire over the last century, so could have been active but undetected in Glasgow for some time.

A *B. sylvestris* male, the four-coloured cuckoo bee, was caught flying in the gardens of one of Glasgow's oldest buildings, the Provan Hall on a scorching May day. Its major host species, *Bombus pratorum*, the early bumblebee was abundant in the grounds. This species has also been found across Scotland. It is a first record for Lanarkshire, although it was recorded from the adjoining counties of Dunbartonshire, at the beginning of the last century and Dumfriesshire in 1975. Given this and the abundance of potential hosts, it is unlikely that this species has only just arrived in Glasgow. Cuckoo bees are often overlooked or misrecorded as social bumblebees. The Scottish records we examined have all been between mid-May and September. These bees are known to be active in Scotland between March and October (Pers. Comm. Murdo Macdonald. October 2011).

C. daviesanus was found foraging once in the Necropolis and on two separate occasions at Bingham's pond in July 2009. Bingham's pond was an artificial boating lake with little wildlife interest. Since 2003 the Glasgow City Council's Biodiversity team has done extensive work to naturalise and enhance it. Many *C. daviesanus* bees, with their blond hairy thoraxes and banded abdomens, were observed foraging there on July 5th in the specially planted wildflower borders (Fig. 1). This species was not listed in the Glasgow Species Audit, so the 2009 sightings were believed to be new county and city records. However, when checking older specimens that had been recently identified in GM collections, a specimen collected in 1984 from Kelvingrove Park was discovered, collected by a former member of staff. These 1984 and 2009 sightings are the first for Lanarkshire, but there are scattered records from all over the country. Whilst these bees may have been exploiting the established green areas such as the Necropolis and Kelvingrove Park for a number of years, Bingham's pond has evidently become a valuable foraging site. All the Scottish records we examined were from between the beginning of July and the beginning of August for this species. This species may be active as early as June in Scotland (Pers. Comm. Murdo Macdonald. October 2011).

To the untrained eye, the *Lasioglossum* bees do not appear to be bees at all. Most species are very small and apparently unhairy, although do have patches or bands of hair on the abdomen on closer inspection. *L. calceatum* was found at Commonhead Moss Local Nature Reserve. It is one of the larger species of *Lasioglossum*. Males are more distinctive than females, with a narrow black and orange-red abdomen. Females have a more rounded abdomen with only tinges of orange-red colouration. Identification of museum specimens revealed that Richard Sutcliffe had collected *L. calceatum* from Glasgow Kelvingrove Park and the Botanical Gardens in 1983 and 1984 respectively, and from Dunbartonshire in 1986. Murray (1940) described it as common in south Dumfriesshire at the end of the 1930s. Modern and historical records reveal that this is a widespread species across Scotland, and further searching in the field is likely to reveal even more records.

Lasioglossum fratellum is a small, black bee with indistinct patches of hair on its abdomen. Modern and historic records have shown it to be widespread across Scotland. Our record from Commonhead Moss is the first for Lanarkshire but it has been found in the neighbouring counties of Renfrewshire, Stirlingshire, Ayrshire and Dunbartonshire. It forages on a range of flower species, such as daisies (*Bellis perennis*) and rosebay willowherb (*Epilobium angustifolium*) (Allen, 2006), which are broadly available, contributing to its wide distribution.

L. smeathmanellum has a characteristic metallic blue-green sheen over the thorax and abdomen (Edwards, 2005). Although not scarce or threatened, as it is common in England, its distribution in Scotland is more limited, being replaced by a closely related (and morphologically very similar) species, *L. cupromicans* further north (Edwards, 2005). Found in Glasgow's city centre, this is a new record for Lanarkshire. Research has revealed a number of records in nearby counties of Ayrshire, Dunbartonshire, Dumfriesshire and Midlothian, and more widely across Scotland. Clark (1909) described this species as fairly common at some sites in Ayrshire at the beginning of the 1900s. So it seems its distribution is more extensive than initially anticipated.

Like *C. daviesanus*, *M. willughbiella*, Willughby's leaf-cutting bee, was also observed on July 5th 2009 foraging in the wild flowers planted around Bingham's pond. There was a published record for this species from Darnley in the South of the city (Renfrewshire) from 1993 (Hancock, 1994) but no records since and nothing previously from Lanarkshire. The south west of Scotland is devoid of records according to the latest distribution maps (BWARS 2010, NBN 2010) but in addition to these recent records, this species has also been active in the adjoining counties of Dumfries and Galloway and Ayrshire over the last century. This species has been recorded between the end of May and end of August in Scotland so far.

Marsham's Nomad bee, *N. marshamella* was captured for the first time at the end of May in Hayburn Lane, a small green corridor in Glasgow's west end. There was a second record less than a week later, from Provan Hall in the east of the city, at the same site and date that the cuckoo bee, *B. sylvestris* sighting. About a dozen of these boldly banded, wasp-like bees were observed investigating entrances to nest burrows of the solitary bee *Andrena scotica* (= *A. carantonica)* in a

south facing garden wall. This species is a cleptoparasite, which parasitizes a few species of *Andrena*. The only host currently known from Glasgow (GSA, 2009) is *Andrena scotica*, which was first confirmed from a residential area in the West End in 2006 from a specimen submitted by Norman Grist (GM). These are the first records for any species of Nomad bees in Lanarkshire, however, in addition to the two Glasgow sightings, *N. marshamella* has been recorded widely across Scotland including from the neighbouring counties of Dunbartonshire, Renfrewshire, Stirlingshire and Dumfries and Galloway. Over 60 years ago Murray (1940) commented that it was the only Nomada he had met with in any number in Dumfriesshire. All the records we examined for this species in Scotland are from between early May and the end of June. They are however known to be active between April and July in Scotland (Pers. Comm. Murdo Macdonald. October 2011).

There are likely to be further interesting specimens in other museums and at other sites in the south west of Scotland relevant to this study. The authors would be interested to hear of them.

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The entomology collection of Dr Clifford Edwards (1913-2009) in Glasgow Museums

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Fig. 1. Clifford Edwards

Clifford Edwards was born in Bristol in 1913 (Fig. 1). He worked in insurance before the Second World War and again on his return from active service. He left the insurance business to attend Southampton University, where he was awarded his BSc. He went on to obtain a PhD before starting as assistant lecturer at the Queen's University, Belfast in 1953.

He moved to Scotland, where he lived and worked for much of his adult life as a professional biologist for the Scottish Marine Biological Association. He studied the zooplankton of the Clyde at Millport between 1956 and 1969. He moved to Dunstaffnage in 1969, shortly after the new marine laboratory opened and worked there until he retired in 1980.

He was awarded a DSc from the University of London in 1975 for his work on the life-histories, systematics, ecology and distribution of British hydroids and hydomedusae; the significance for classification of the Hydroida and history of the study of Hydroida. Whilst he had not published as much as some DSc applicants, his work was of such quality he was deemed deserving. Dr Paul Cornelius, a fellow Cnidarian expert, formerly of the Natural History Museum, London described his publications and the man himself as meticulous and totally reliable.

Dr Edwards specialised in rearing and describing hydroids. There was much taxonomic confusion in the group, with the early and later life stages being given different species names. With the assistance of Martyn Harvey, he managed to establish what a number of these organisms looked like at each stage of development, clearing up the taxonomy.. He has a Hydrozoan named in his honour, *Sarsia cliffordi* Brinckmann-Voss, 1989. Dr Anita Brinkmann-Voss, the author, said that she and her Canadian colleagues had greatly admired his work and referred to him as an 'outstanding scientist'. Looking at Dr Edwards' entomology collection it is apparent that he also brought professional scientific rigour to his 'amateur' entomological investigations.

The collection contains over 100 store boxes of beautifully preserved pinned specimens from the West of Scotland and beyond (Fig. 2). There are numerous boxes of Scottish material, including 17 boxes of Hymenoptera, 7 of Coleoptera and 2 of Diptera. The remaining boxes are lepidoptera. Most of the collection is contemporary, collected by Clifford Edwards between the 1930s and the 1980s. He did not drive so was largely reliant on public transport and his fondness for cycling to find his specimens; consequently many come from in and around Oban. There are often a large number of examples of the same species collected from different locations and on different dates, including speckled woods, marsh fritillaries and burnet moths. Whether this sampling was to support particular investigations or just reflect his strong collector's instinct remains to be established. His colleagues knew he was knowledgeable about insects, amongst many other things, but had no idea he actually collected insects. Dr Edward's sister said that Clifford was always a keen insect collector.

In addition to the store boxes there are several boxes of papered lepidoptera that were collected by Dr Edwards in the 1970s and 80s, from Ireland, Dorset and Cornwall amongst others. Dr Edwards regularly took holidays in the South West of England. There are a number of more aged tins of unlabelled specimens wrapped in paper of foreign origin. Several specimens are wrapped in army stationary and one of the tins is dated 1942, so were probably collected by him during his military service with the Hampshire Regiment. There are specimens in a tin labelled with Perugia, dated the 8th August 1945, just over a year after the Italian town was seized by the British troops. Martyn Harvey remembers Dr Edwards mentioning that he worked making maps for the army, following the invading forces through North Africa and Italy.

Dr Edwards had purchased and collected foreign butterfly and moth specimens to complement and enhance his collected material. Between 1970 and 1974, he spent nearly £1000 on specimens. There are

examples purchased from Worldwide Butterflies, R. N. Baxter, the Butterfly Centre, Saruman Butterflies, J. W. Smale, L. Christie, G. Hanrahan and K. P and D. J. Tolhurst. There are two specimens labelled as types in the box of Indian Lycaenid butterflies, which require some research to determine their authenticity.

Dr Clifford Edwards bequeathed his entomology collection to the Glasgow Natural History Society (GNHS) in the winter of 2009. Glasgow Museums (GM) was given first refusal of the specimens. In addition to the insect collection, Dr Edwards amassed a considerable natural history library, which he left to the Glasgow University Library (GUL). The GUL contacted GM around the same time to offer the museum the books that they did not require.

Early in 2010, Jeanne Robinson, Curator of Entomology went to assess the insect and library holdings in Dr Edwards' home. GM subsequently agreed to take all of the insect collection and a selection of the books. Scottish insect collections are few and far between and this collection complements and enhances GM's existing holdings in line with the collecting policy.

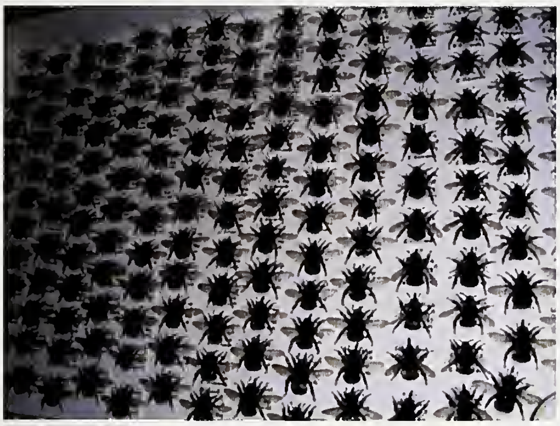

Fig. 2. A selection of Scottish bumblebees from Clifford Edwards' collection

Thus GM has acquired a large volume of reference material concerning the taxonomy and biology of lepidoptera of the world and a select few about other groups of organisms.

The collection has been accessioned as Z.2010.19 and can be viewed by appointment with the Entomology curator at the Glasgow Museums Resource Centre (GMRC). Dr Edward's books are also housed at GMRC and a list of these volumes acquired is in preparation.

Many thanks to May Edwards, Allan Davis, Clive Craik, Paul Cornelius, Anita Brinkmann-Voss and Martyn Harvey for providing biographical information about Clifford Edwards. If you knew Dr Edwards and have any additional information for inclusion in GM's biographical files please contact the author.

Adventures with Amphibians

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INTRODUCTION

A retirement lecture gives an opportunity for looking back and reviewing, and attempting to give coherence to a career. I can think of scientists who set off early on a theme and pursued it doggedly throughout their careers. Mine hasn't been like that. I began as an avian embryologist, then got interested in the reproductive ecology of amphibians. Then, through involvement in student expeditions overseas, marine turtle life histories and conservation developed as a side interest. Along the line bioethics and evolution education became research themes too, so there is little coherence, but diversity of interests is not such a bad thing for a biologist.

I've chosen to concentrate here on amphibians, and have called my experiences 'Adventures', partly because amphibian work is often at night, and in the tropics, night work in swamps can lead to all sorts of unexpected happenings. 'Chance encounters might be a better title, because chance has played a major part in the research I've been able to do. My interest in amphibians grew out of teaching a course on reproductive biology, mainly in the vertebrates. In 1982, I got the chance to spend five months study leave in Trinidad. This was quite serendipitous. Robin Bruce, an ex-student who had been with us on an expedition to Iceland (1972) obtained his first lecturing post at the University of the West Indies in Trinidad. He reported that Trinidad and Tobago were good places to study frogs, and that his head of department had written the guide to them (Kenny, 1969). So my family and I went to Trinidad and I got hooked for life, having now visited the islands more than 20 times. In recent years, I've become involved in amphibian work in the UK too, but in this lecture, I'll concentrate on four themes from our Trinidad work.

FOUR AMPHIBIAN ADVENTURES

Foam-nesting frogs

My first serious work in Trinidad in 1982 shows the influence of luck and chance. We arrived in the dry season with not many frogs around. Then there was some patchy rain, and puddles began forming on a piece of waste ground on the UWI campus: I passed these each day. After a heavy shower, I was surprised to find well developed tadpoles in the puddle as well as floating foam nests. I was fairly sure there had been no tadpoles previously. A few dry days and the puddle

dried up. Hard luck on these tadpoles and the foam nests, I thought, but then it rained again, and there were tadpoles again. What was going on? Next time it dried, I searched the damp mud at the low point and found, under dead leaves, an aggregation of tadpoles, wriggling about in a little heap of froth. A bit more searching, and in a burrow, under a stone was a white foam nest, containing early hatchling tadpoles. This was my first encounter with the whistling frog *Leptodactylus fuscus,* and it was a matter of luck because the ground staff tidied up the area a few years later and the frog populations disappeared. *L. fuscus* is a foam-nesting species, and often shares breeding pools with another foam nester, the tungara frog *Engystomops pustulosus*, which produces the floating foam.

An aside at this point: one of the real bugbears of working on tropical amphibians is unstable taxonomy. This is partly a consequence of colonial times with French, Dutch, Spanish and British natural historians giving different names to what turned out to be the same species, then having to sort out the mess. *L. fuscus* has had NINE names: *Rana fusca* (1799), *Rana typhonia, Rana sibilatrix, Leptodactylus typhonius, Cystignathus typhonius, Cystignathus fuscus, Leptodactylus sibilator, Leptodactylus sibilatrix, Leptodactylus fuscus* (1983). More recently, molecular phylogenetics have revolutionised our understanding of the evolutionary relationships of amphibians and unleashed a continuing spasm of taxonomic revision. Few of the frog species I first encountered in Trinidad in 1982 now have the same names. This is a curse, but also an opportunity: the unravelling of relationships has generated many opportunities to think again about the evolution of life histories and other adaptive features, as we'll see later.

When I started, the Trinidad tungara frog was *Eupemphix* then *Physalaemus*, now *Engystomops* and it is now in a separate family, the Leiuperidae, no longer a leptodactylid. Here are some of the things we found about these two frogs (Downie & Nicholls, 2004).

Leptodactylus fuscus

- Eggs are deposited in hidden burrows close to where temporary pools form. Burrows are closed by mud 'lids'. Most nests are deposited on dry nights, not after rain. We find them by prodding a spoon handle into the mud.
- Hatching occurs after 3 days. Tadpoles make a new kind of foam via oral secretions, and tadpoles can remain in this, without developing further, up to 4 weeks.
- If heavy rain falls, the tadpoles – already developed beyond hatching stage, enter the pool as the nest opens up – and are capable of eating newly deposited eggs of other species.
- The longer tadpoles stay in foam, the poorer their condition, and less able they are to grow successfully to metamorphosis.
- Burrow nests seem an excellent adaptation to an unpredictable environment but they do face a threat: a species of phorid fly, 'frogflies', can deposit their eggs in the foam and become maggots fast enough to destroy the frog embryos (this turned out to be a new species that we were able to describe).
- If the pond dries up, tadpoles can shelter under leaves or rocks on the damp mud surface and can survive several days – our original observation.

Engystomops pustulosus

- Floating foam nests are laid after rains. Hatching occurs after 2-3 days, with some larvae emerging late from the nest, possibly allowing development to a more advanced stage.
- Tadpoles have no ability to survive if the pond dries up.
- In competition with *L. fuscus* tadpoles, *E. pustulosus* tadpoles fare poorly – taking longer to reach metamorphosis and at a smaller size.

Conclusion: *L. fuscus* seems the superior competitor when pools are temporary and rainfall is unpredictable. Yet you see *E. pustulosus* everywhere: it seems especially well suited to human-related habitats like flooded tyre-ruts and must be a very effective colonizer of disturbed habitats. Perhaps the larger clutch size (about 100 for *L. fuscus*; 400 for *E. pustulosus*) is important here.

Phyllomedusa: one of the charismatic poster frogs

Here we have a piece of Glasgow Zoological history (Downie, 1997). The first generally cited paper on *Phyllomedusa* is by J.S. Budgett (1899) – a friend and colleague of John Graham Kerr's before Kerr came to Glasgow. Budgett's observations of *Phyllomedusa* were made on the Gran Chaco (Argentina-Paraguay) expedition where Kerr collected the lungfish embryos that were to be his main study. The second widely cited paper is by Wilfrid Agar (1910): Agar joined Graham Kerr in the Zoology Department in Glasgow and made observations on *Phyllomedusa* during another lungfish collecting trip in 1907-8 (not accompanied by Kerr). Agar eventually became Professor of Zoology in Melbourne, Australia from 1920. Both Budgett and Agar made important observations on *Phyllomedusa* reproduction, and we have recently been able to extend these.

The Phyllomedusinae are a sub-family of a major treefrog family, the Hylidae. There are (so far) 60 species of Phyllomedusine frogs, distributed throughout the neo-tropics, from Argentina through Central America and into Southern Mexico (Frost, 2011). There are two main genera, *Agalychnis* (including the widely-photographed *A. callidryas* – the red-eyed treefrog) and *Phyllomedusa*. Phyllomedusines do not deposit their eggs in water. In *Agalychnis* eggs are deposited in clumps on open leaves overhanging water in wet rainforest. Since 1996, Karen Warkentin has published a large number of studies on *Agalychnis*

based on her original finding that *Agalychnis* development shows considerable plasticity: egg clutches are heavily predated by snakes, but embryos can detect them and – within limits – hatch prematurely to escape the snakes, which tend not to swim after them. There is a classic trade off in operation here: embryos which develop fully on the leaf before hatching do better once they reach water than premature hatchlings: but if snakes attack, all embryos may be eaten, so premature hatching gives them a survival chance (Warkentin, 1999).

In comparison, *Phyllomedusa* incubation and hatching has been comparatively neglected, with few publications since Pyburn (1980). In Trinidad, we have *Phyllomedusa trinitatis* (which also occurs in northern Venezuela): in *Phyllomedusa*, eggs are deposited as an elongated clump on a leaf, but the adults use their limbs to fold the leaf around the clump, often managing to enclose the egg clump more or less completely – with an opening top and bottom. These openings are plugged by dense masses of jelly. Throughout the egg clutch are scattered large numbers of small round jelly capsules. The jelly capsules and plugs, and the eggs themselves (with thin jelly coats) are adhesive – so once the leaf has been folded over the clutch, it sticks in place. Generally, the leaf-nest overhangs a pool of water, so when the embryos hatch and emerge from the nest, they drop into the water below. But it seems not always possible for adults ready to reproduce to find a suitable leaf or leaves in a good place. They have two solutions. First, there may be better leaves a short distance away from the pool: once hatchlings emerge, they land on the ground, and are well capable of moving to water by flipping movements of their already powerful tails. Second, they can make rudimentary nests even from blades of grass overhanging a pool: we don't think these are very successful, and it would be interesting to investigate what factors drive frogs to make this choice.

Agar (1910) suggested that the jelly capsules help hydrate the eggs, since he noticed that during incubation, eggs swell with fluid and jelly capsules shrink: the hydration role of jelly capsules has been confirmed (Pyburn, 1980). How the frog's oviduct is able to make separate secretory releases (top and bottom jelly plugs, quite complex structurally; scattered capsules; a thin jelly coat round each egg), is not clear.

What we've found (work in preparation):

- Contrary to previous reports, eggs do develop in aquatic media, the better the later they enter water and the better if the medium is a dilute balanced salt solution.
- The covering leaves do not need to be alive: incubation in cut leaf-nests is as successful as in live leaf-nests.
- Hatching of individual eggs can be stimulated by immersion in water, once they are hatching competent, or by contact with already hatched larvae, by a kind of chain reaction.
- Emergence from the nest does not occur until the lower jelly plug has been dissolved – probably as a result of enzymes released by larval hatching gland cells.
- Because of the time-lag between individual egg hatching and nest emergence, we do not think that premature hatching in response to predator attacks is relevant in *Phyllomedusa*. Rather, the leaf-fold nest and jelly plugs act as effective barriers to many kinds of predators.
- But there is a puzzle, yet to be resolved: how do *Phyllomedusa* eggs respire when they are apparently completely cut off from the air by leaf and jelly?

The diversity of embryo-specific surface structures

I've been fortunate for some years to have Mohsen Nokhbatolfoghahai working with me on the diversity of embryo and larval specific structures such as:

- Surface ciliation
- External gills
- Cement glands
- Hatching gland cells
- Tails

Scanning electron microscopy of these structures produces beautiful images (for example, Nokhbatolfoghahai & Downie, 2005). The example discussed here is that of the tails of direct-developing frogs, and luck is again important.

There are several lineages of anurans where a trend involving egg size increase and incubation on land has led to the suppression of the tadpole stage, and direct development to a juvenile frog. Generally, this involves the deletion from development of several larval specific structures, such as cement glands and external gills. But the tail is retained in modified form through the incubation stage, usually being resorbed just before hatching. We had included some observations on a Trinidad species *Eleutherodactylus urichi* in our paper on surface ciliation (Nokhbatolfoghahai *et al.*, 2005).

Then Nicola Mitchell (Western Australia) asked us to look at some direct-developing embryos of the turtle frog, and we elected to do this as a more detailed comparison with *Eleutherodactylus*. However, molecular phylogenetics had by then sub-divided the vast neo-tropical genus *Eleutherodactylus* (800+ species) into three main ancient sub-lineages and given the whole group super-family status (Hedges *et al.*, 2008). Our *Eleutherodactylus* was no longer in that genus: now *Pristimantis*, whereas the only other member of the group whose embryos had been looked at in detail, the coqui frog of Puerto Rico, remained *Eleutherodactylus coqui*. This taxonomic revision made us look harder, and we discovered a very surprising feature (Nokhbatolfoghahai *et al.*, 2010). In most direct-developing frogs, the tail is retained, but as a respiratory organ with highly vascular skin. In the

coqui frog and in the turtle frog, this involves some elongation of the tail fins to increase respiratory exchange surface area. But in *Pristimantis urichi*, we found that tail surface area expanded not by fin elongation, but by lateral expansion of skin, blood vessels and connective tissue. In coqui frogs and turtle frogs, the tail has well developed muscle, allowing the tail to move from side to side. In *Pristimantis*, the muscle is reduced, so that the tail has become a fixed respiratory organ, with its outer surface close to the inner wall of the vitelline membrane – in some ways reminiscent of the allantois in amniote embryos (though referees would not allow us to suggest that analogy!). Will this evolutionary innovation be found in other *Pristimantis*?

Manno the stream frog

I talked about our work on *Mannophryne trinitatis*, Trinidad's only dendrobatid (now aromobatid) in my 2005 Presidential Address (Downie, 2005), so I won't go over this in detail again. However, there is a footnote to the story. *M. trinitatis* males guard the eggs on land till they hatch. The male then carries the tadpoles on his back till he finds a suitable stream to deposit them into. Our work showed that suitable streams can be hard to find – since the males avoid leaving tadpoles in streams containing predators such as *Rivulus* fish. This is another case of good luck: for some time, I'd wondered where the males deposited their tadpoles, because we knew of many streams with large frog population but no tadpoles (but abundant *Rivulus*). Then one trip we chanced on a stream with hundreds of tadpoles (and no fish). Since each male only carries about 12 tadpoles, clearly frogs were coming to this stream from some distance, to avoid fish predation. Eventually, I realised that these males are on a dangerous quest and wrote it up as a children's story. We've now successfully told it – in the form of a play – to children's groups in Scotland and Trinidad. In my view, we need to develop stories about animals that can grab the attention of young people and help re-connect them with nature – if we are to halt the alarming declines in biodiversity we see everywhere – and in amphibians in particular.

To give the story 'human' interest, Manno the male stream frog meets a female called Trini, and really fancies her. Trini is older and a bit bossy and when Manno suggests that after he's found a good stream for their first batch of tadpoles, that they might get together again "to get to know each other better" – Trini is pretty sharp with him.

I put in the idea of Manno and Trini becoming a faithful pair to add some human interest, and knowing that monogamy isn't supposed to happen in any frogs. However, a recent report shows that it does, and in a species of the same general type as *M. trinitatis*. In the mimic poison frog *Ranitomeya imitator*, males transport tadpoles on their backs to tiny bromeliad tanks. There is so little water and food per tank that tadpole growth depends on the female depositing trophic eggs to feed the tadpoles. The male stays on guard, and calls the female when more food is needed. Clearly, they care for the young together – and a possible hypothesis, yet to be tested, is that if the parents are successful in their different parental roles, it makes sense in terms of Darwinian fitness to remain together as a pair – for life (Kokko & Jennions, 2010).

CONCLUSION

Most people are now aware of the serious threat to amphibian populations around the world. In my view, we need to do a lot more of the basic natural history work I've described, in order to understand better the lives of amphibians. If we don't, we are unlikely to devise sensible and effective conservation procedures.

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The migrant moth, small marbled *Eublemma parva*, in central Scotland in 2011

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The small marbled *Eublemma parva* is a small noctuid moth resident in southern Europe and parts of Africa and Asia. As an immigrant from southern Europe to the UK, it is most often recorded from the coastal counties of southern England with the density of records decreasing northwards. It sometimes produces larvae and late season adults, but there is no evidence of over-wintering in the UK. Most UK sources give common fleabane *Pulicaria dysenterica* and ploughman's spikenard *Inula conyzae* as larval foodplants. Other foodplants have been noted elsewhere in Europe, including several species that are on the British list.
In appearance, the small marbled is very small for a member of the family Noctuidae, and quite likely to be mistaken as belonging to one of the microlepidoteran families. The base of the forewings have a washed-out tan colour, increasing in intensity toward the central band where there is usually an abrupt change to white, thus forming a central line, followed by a renewed darkening toward a second crossline which has a shape that has been likened to a question-mark (when viewed from the trailing edge of the right forewing). Beyond the second crossline there is another somewhat diffuse tan-coloured band which extends toward the wing tip.
According to South (1920) the small marbled (referred to by South as *Thalcopares parva*) was first noted in Britain in July 1844 in South Devon. It is widely reported that there was a particularly dramatic influx in 1953. As far as can be ascertained, the first Scottish record was by R. Knill-Jones at Parkgate, Dumfriesshire, VC72, inferred 1km grid reference NY0287, where it was attracted to mercury vapour light on 10th July 1982 (Bretherton & Chalmers-Hunt, 1983, p149). Bretherton and Chalmers-Hunt noted (p89) that this was the only record of an adult in that year though many larvae were found in south Devon in August and September and adults were reared from these larvae. The second Scottish record, also in the south-west, was by R. Mearns at Clanyard Mill, Drummore, Wigtownshire, VC74, inferred 1km grid reference NX1037, on 20th June 1998 (Skinner & Collins, 2000, p246). The latter specimen is now in the National Museums of Scotland in Edinburgh. In England too, 1998 was a good year for small marbled with records from seven English vice-counties, from the Scillies in the south-west to Holy Island in the north-east, plus a record from the Isle of Man. Larvae were found in Portland.
In 2011, there were two further Scottish records of adult small marbled, both in Central Scotland. On the east coast, the first author, C.C., caught one on 04 July 2011 in an 8W actinic portable Heath trap in her garden in Abercorn, West Lothian VC84, grid ref NT080789. Subsequently, in the west, D.C. and G.C. caught one on 27 July 2011 in a 40w actinic trap in their garden in Ascog, Isle of Bute, VC100, grid ref NS105639. Informal reports indicate that 2011 has been a good year for small marbled in the UK as a whole.
Thus, as far as we are aware, there have now been just four records of the small marbled in Scotland, in four different vice counties, the furthest north being the West Lothian record.

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The Australian landhopper, *Arcitalitrus dorrieni* (Hunt, 1925), Crustacea, Amphipoda, in Glasgow

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The landhopper *Arcitalitrus dorrieni*, was found in Glasgow amongst leaf litter and under wood and stones in bushes at the southern end of the public car park, Bunhouse Road, in April, 2009. Landhoppers are obvious when the surface of the leaf litter is disturbed or exposed (Figure 1). Their dark brown shiny bodies can be seen as they jump several centimetres in the air before burying rapidly back into the dead leaves. This behaviour is typical of the animal and immediately recognisable in the field. The population appears to be established as they have been seen on several occasions since then. Some specimens were collected and are preserved in the Hunterian Museum (Zoology). It was conjectured that the landhoppers might have been transported to the site during some recent landscaping at the car park. The City Council maintains a large depot at Bellahouston Park where shrubs and other plants are kept prior to use. If plants had been brought from there which already contained landhoppers in the soil around their roots this could explain their origin on a local scale. Searching under bushes around the entrance to the depot did reveal landhoppers, showing this was indeed the probable immediate source. These animals can be transported over long distances by such means. The original transfer from Australia to Europe was in plants, probably tree ferns, imported to Tresco Abbey Gardens in the Scillies, sometime prior to 1924.

Previous occurrences in Scotland are from the three Scottish Islands of Colonsay (Moore & Spicer, 1986), Gigha (Cowling, et al., 2004) and Arran (Brodick Castle Gardens on 13 September, 2010, unpublished record from a British Isopod and Myriapod Group field meeting), plus two mainland localities, Inverewe Garden, Wester Ross, 29 June 1998 and Loch Laich, Appin, Argyll, 21 June 2001, on both these occasions by G.B. Corbet (personal communication). A survey by questionnaire was conducted by Cowling and her colleagues using a wide distribution of posters and questionnaires over the whole of Britain. From this about 170 negative records were created for Scotland. Thus, the finding of landhoppers in Glasgow would seem to be a recent establishment of the species. Added to a few sites in London where the landhopper has become resident these seem to be the only known established urban populations in the British Isles.

Fig. 1. Australian land hoppers amongst debris, Bunhouse Road, Glasgow, 2009

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Miscellaneous invertebrates recorded from the Outer Hebrides, 2010

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While attending the Botanical Society of the British Isles field meeting on North Uist in August 2010, the opportunity was taken to collect invertebrates. The records presented here fall into two categories, being either the less common species found on North Uist, or lengthier species lists from two smaller and less well recorded islands. The three flies recorded from Hermetray may be the first records of Diptera from this island (Skidmore, 2009).The species' status are taken from Foster (2010) for aquatic beetles, Hyman & Parsons (1992) for other beetles, and Falk (1991) for flies.

Heteroptera

Halosalda lateralis: 2 in saltmarsh, Claggan Sollas, NF818758, 5 August. A shorebug found in

saltmarshes.

Homoptera
Euconomelus lepidus: 1 male and 3 females swept from moss beside Loch a' Roe, NF69077045, 2 August. A small plant-hopper associated with rushes, *Juncus* spp.

Coleoptera
Chaetarthria simillima: 4 sieved from moss beside Loch a' Roe, NF69077045, 2 August. A tiny water beetle, Nationally Scarce, described new to science as a segregate of *C. seminulum* in 2003. See Levey (2005) for how to distinguish the species and Foster (2009) for distribution maps. *C. simillima* has been recorded previously from the southern end of the Outer Hebrides.
Cercyon littoralis: 2 in beach driftline, Traigh Iar, NF816767, 5 August. A small beetle, Nationally Scarce, found in coastal driftlines.
Gyrinus minutus: 2 males in a small peat pool near Loch Sgadabhagh, NF87136725, 3 August. A Nationally Scarce whirligig beetle.
Silpha tyrolensis: 1 on dunes, Machair Leathann, NF820772, 1 August; 1 dead on machair, Claggan Sollas, NF806761, 5 August. A Nationally Scarce carrion beetle, possibly a predator of molluscs according to Hyman & Parsons (1992). The specimen from Claggan Sollas was in a bucket part full of water which had acted as an insect trap and contained dozens of dor beetles *Geotrupes stercorarius*, many of them decomposing.

Diptera
Nemotelus uliginosus: female in saltmarsh, Claggan Sollas, NF818758, 5 August. A soldierfly which breeds in saltmarsh.
Gimnomera tarsea: two females swept from moss beside Loch a' Roe, NF69077045, 2 August. A Nationally Scarce scathophagid fly which breeds in the seed heads of marsh lousewort *Pedicularis palustris*.
Calliphora uralensis: 1 male and 2 females collected from a group of 10 bluebottles in the porch of Sheillaidh, Sollas, NF81957536, 11 pm, 4 August; 1 male on beach, Traigh Iar, NF816767, 5 August. A boreal blowfly or bluebottle, Red Data Book category 3, Rare, restricted in Great Britain to Scotland, and mainly coastal (Davies, 1987).

Hymenoptera
Bombus muscorum ssp. *liepeterseni*: worker dead on dunes, Machair Leathann, NF820772, 1 August; worker, machair, Balranald, NF697698, 2 August. We were told by the Balranald warden Jamie Boyle that the bumblebee *Bombus muscorum* is frequent on North Uist. However, the two collected specimens have black hairs on the abdomen, which indicates they should be *B. pascuorum* according to Edwards & Jenner (2009), a species not found in the Outer Hebrides. The issue was resolved by Dr Oliver Prys-Jones who identified them as this subspecies of *muscorum*, which does have black hairs, as explained in his recent book (Prys-Jones, Corbet & Hopkins 2011). In Britain, it is known only from the Outer Hebrides.

Hermetray, 4 August
Small pool in valley bog, NF98687412: *Agabus bipustulatus*, *Hydroporus gyllenhalii*, *H. pubescens*, *H. tristis*, *Enochrus fuscipennis* (aquatic Coleoptera). Lake, NF988741: *Ischnura elegans*, *Sympetrum nigrescens* det. R. Youngmann (Odonata). Same lake, NF989739: *Mystacides azurea*, 2 females (Trichoptera). Rocky shore, NF99047398: *Ligia oceanica* (Crustacea, Isopoda). Driftline of sand and shingle beach, NF98637367: *Fucellia tergina* male, *Scathophaga litorea* (Diptera). Freshwater spring by beach, NF98617371: *Hydroporus pubescens* (aquatic Coleoptera). Pool above north end of beach, NF98587371: *Gammarus duebeni* (Crustacea, Amphipoda). Bay, NF98557442: *Petrobius brevistylis* (Thysanura), *Forficula auricularia* (Dermaptera), *Clivina fossor*, *Ocypus ater* (Coleoptera), *Eristalinus aeneus* (Diptera), *Porcellio scaber* (Crustacea, Isopoda).

Ronay, 6 August
Seepage, NF88775593: *Agabus bipustulatus*, *Hydroporus nigrita*, *Anacaena globulus*, *Laccobius bipunctatus* (aquatic Coleoptera), Fox moth *Macrothylacia rubi* larvae (Lepidoptera). Under litter on turf, NF887559: *Forficula auricularia* (Dermaptera), *Philoscia muscorum* (Crustacea, Isopoda). Moorland, NF894558: Knotgrass moth *Acronicta rumicis* 2 larvae (Lepidoptera). Moorland, NF899557: Magpie moth *Abraxas grossulariata*, Garden Tiger *Arctia caja* (Lepidoptera). Small peaty lake, NF90085566: *Sympetrum danae* larva (Odonata), *Agabus arcticus*, *Enochrus fuscipennis* (aquatic Coleoptera). Another small lake, NF89845569: *Hydroporus obscurus*, *Gyrinus minutus*, *G. substriatus* (aquatic Coleoptera). Shore of rocky lake, NF89715537: Emperor moth *Saturnia pavonia* larva (Lepidoptera).

I wish to thank Wendy McCarthy and Martyn Stead for driving me to and around the island; Paul Smith for arranging the trips to Hermetray and Ronay; Rosemarie MacCuish of Sheillaidh, Sollas, for accommodation; Dmitri Logunov of Manchester Museum for access to Silphidae reference specimens; and Dr Oliver Prys-Jones for solving the bumblebee conundrum.

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A photograph of a teacher-training course in marine zoology at Millport (1914)

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At a recent members' evening of Cumbrae Historical Society, James Peacock showed me an old unused postcard from his collection featuring a photograph (Fig. 1) taken at the Marine Station, Millport on 6 July 1914. The photographer, as recorded on the reverse, was George Keppie, Stuart Street, Millport.[1] It depicts a class of school teachers studying junior and senior courses in nature study (course number 573G; marine zoology) held during the first fortnight of July 1914. Few such early Millport class photographs exist.

Fig. 1. A class photograph of school teachers at the Marine Station, Millport, 6 July 1914, against a backdrop of the, now ivy-clad, Deil's dyke. Seated in the front row (left to right) number 1, Professor L. A. L. King (St Mungo's College of Medicine, Glasgow; incorporated since 1947 into Glasgow University's medical faculty); number 3, J. G. Connell; number 5, Dr J. F. Gemmill. Number 7 may be Mr Frank W. Young, His Majesty's Chief Inspector for Schools for the West of Scotland who reported on the quality of these classes. One of the walrus-moustached, flat-cap-wearing gentleman (back row, centre) could be John Peden, the Laboratory Attendant, but which one of the two such gentlemen shown, I cannot be sure. Miss Alice Jones is likely to be one of the ladies in the front row (photograph by G. Keppie).

According to the annual report of the Scottish Marine Biological Association (SMBA, 1914: 12–13, 73) 18 students attended in July 1914: seven taking the junior course (Course I) and 11 taking the senior course (Course II). The instructors on the course were John Gibson Connell FRMS (c.1876–1946) (from Glasgow Provincial Training College; subsequently to become Jordanhill College, now the Faculty of Education, Strathclyde University), who conducted the senior course, and Dr James Fairlie Gemmill (1867–1926) (Glasgow University), assisted by Miss Alice Jones, who conducted the junior course: "much work of excellent character was accomplished, and all the students received certificates from the Glasgow Provincial Committee" (SMBA 1914: 12–13): "it is interesting to note that, while most of the teachers enrolled in these classes, were from Glasgow and the West of Scotland, two were from Aberdeen, two were from Falkirk, and one from India."

Prizes, as a result of voluntary competition, were awarded to: Course I, 1. Jessie A. Hutcheon, Victoria Road School, Aberdeen, 2. William C. Forsyth, BSc, Glasgow; Course II, 1. Mary D. Currie, MA, Hutchesons' Girls' Grammar School, Glasgow, 2.George Nelson, Northern Public School, Falkirk'.

The students were listed (SMBA, 1914: 73) as follows: Course I (Annie E. Craib, William C. Forsyth, Jessie A. Hutcheon, Sara C. Jones, Wilhelmina M. G. Mackenzie, James Pryde, William Rowatt), Course II (Isabella Abel, Mary D. Currie,[2] Jemima Downie,[3] Georgina M'Ilvain, Lillie A. M'Ilvain, James Mather, John D. Milne, George Nelson, Annie M. Russell,[4] George Russell, James Shearer).

I have been able to identify only three persons by comparing Fig. 1 (see caption) with an earlier (1909?) Millport teachers' class photograph (Moore, 2008, Fig. 5). Note that over half of the students were women. Sixty-three percent of the class shown in Millport's 1909(?) photograph were women (Moore, 2008, Fig. 5). By 1911, nearly three-quarters of teachers in Scotland were women.[5] Between 1880 and 1914, Scottish school masters commanded higher salaries than their English counterparts, whereas Scottish school mistresses (higher in number than male teachers

across the United Kingdom) were consistently less well paid than English women teachers, although they were more highly qualified (Corr, 1997; Hulme, 2011).

ACKNOWLEDGEMENT

I am grateful to Mr James Peacock, Millport, for bringing this postcard to my attention.

NOTES

[1] Keppie, George (aka George Kippie) [(c.1871–1917)]. Photographers of Great Britain and Ireland, 1840–1940 (URL, accessed 17 January 2012, http://www.victorianphotographers.co.uk/index.php/victorian-photographers-k/keppie-george-aka-george-kippie-/p_30356.html).

[2] Mary Darroch Currie (1878–1936) graduated MA from Glasgow University in 1905. Isabella Blacklock (b. 1869) had been the first female to graduate MA from Glasgow University, graduating in 1895 (URL, accessed 13 January 2012, http://www.universitystory.gla.ac.uk/alumni/help/finding-graduates/). Women were only permitted to study at Scottish universities after 1892.

[3] A Jemima Wright Downie (1876–1965) graduated MA from Glasgow University in 1902.

[4] Annie Russell, I know, taught at Kilmarnock Academy.

[5] Knox, W. W., The Scottish educational system 1840–1940 (URL, accessed 12 January 2012, www.scran.ac.uk/Scotland/pdf/SP2_1Education.pdf).

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Correction to the statistical note in 'Gulliver, R., 2011. Patterns of flowering on continuously-grazed dune and machair on Colonsay. The Glasgow Naturalist 25 (3) 19-28'

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INTRODUCTION

The data analyses in the article on the phenology of dune and machair communities on Colonsay were correct. However the statistical note in the Methods section was incorrect. The author apologises for this error. A revised set of notes follows.

MAIN TEXT

No overlap between samples; t, z and U test

When there is no overlap between samples (that is, where all the values in one sample are greater in magnitude than all the values in the other) and the data is parametric (that is, the distribution of sample values is well approximated by a Normal distribution), the t or z test should be applied.

For sample sizes of 5 to 20 of non parametric data, and using the form of Mann Whitney U test where the lower of the two U values is the test statistic, it is advisable procedure that a test be applied. However, in these cases the outcome of operating the test is known in advance. The lower value of U will be zero. Reference to the tabulated values of U will show that significance has been obtained and that the null hypothesis can be rejected. For sample sizes of above 20 a formula exists for converting the lower U value to z (Campbell, 1974 p61). For non overlapping samples n1=n2=21, z has a probability of less than 0.1% using the formula. Hence a very highly significant difference will be obtained in all cases where both n1 and n2 are above 20 for non overlapping samples.

For the Mann Whitney U test some tabulated values use the higher of the two U values. Use of the lower value means there is always the same value of U which shows the maximum difference between samples i.e. 0. Use of the upper value means that the values of U associated with maximum difference between samples varies with sample size.

Paired data: the case when the trend in every pair of values is the same throughout; paired t, paired z and Wilcoxon tests

When the trend in every pair of values is the same throughout (i.e. the larger value in each pair always belongs to the same one of the two conditions) for parametric data (where the differences between the two values in each pair give a distribution which is well approximated by a Normal curve), the paired t, or paired z test should be applied.

Where the trend is the same throughout all the pairs of values of non parametric data, for sample sizes of 7 to 25, it is advisable procedure that a Wilcoxon test be applied. However, in these cases the outcome of operating the test is known in advance. The test statistic W (T) i.e. the lower value of R+ or R- will be zero. Reference to the tabulated values of W will show that significance has been obtained and that the null hypothesis can be rejected. For sample sizes of above

25 a formula exists for converting the lower W (T) value to z (Campbell, 1974 p66). For pairs of values when the trend is the same throughout for n=26, z has a probability of less than 0.1% using the formula (n=26 excludes zero differences). Hence a very highly significant difference will be obtained for all paired values of n above 26 when the trend is the same throughout.

Some tabulated values of W (T) use the higher value of R+ or R-. Use of the lower value means there is always the same value of W (T) which shows the maximum difference between the paired replicates i.e. 0. Use of the upper value of R+ or R- means that the values associated with maximum difference between the paired replicates varies with sample size.

Biologists do not always agree on whether data are paired or not. In case of doubt, assume data are not paired.

ACKNOWLEDGMENT
The helpful advice provided by Dr Tim Sparks is gratefully acknowledged. However, the total responsibility for the text rests with the author.

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SUPPLEMENT
The application of a Mann Whitney U test to the case of non overlap on p21 of Gulliver 2011 results in a significant difference being generated, as does the application of a Wilcoxon test to the case of the trend being the same throughout in all pairs of values on p22. NB the median of 23 for 4m^2 machair quadrats on p21 & p23 is correct, the value in Table 1 should be 23 not 25, author's error.

The most northerly documented record of the green alga *Hydrodictyon reticulatum* (water-net) in the UK

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Strathclyde Loch is located within Strathclyde Country Park, Motherwell (NS 73290 56980) and is designated as a Sensitive Area (Eutrophic) under the Urban Waste Water Treatment Directive, and of poor ecological potential under current Water Framework Directive (WFD) classification. A macrophyte survey of the loch was carried out in September 2011 by Alison McManus, Thomas Coy and Jan Krokowski (SEPA). This was done as part of SEPA's WFD monitoring and classification. During the survey the invasive nuisance green alga *Hydrodictyon reticulatum* (L.) Bory de Saint-Vincent, 1824 (water-net: Fig. 1) was discovered at one of the sampling points and is believed to be the most northerly documented record of this species in the UK.

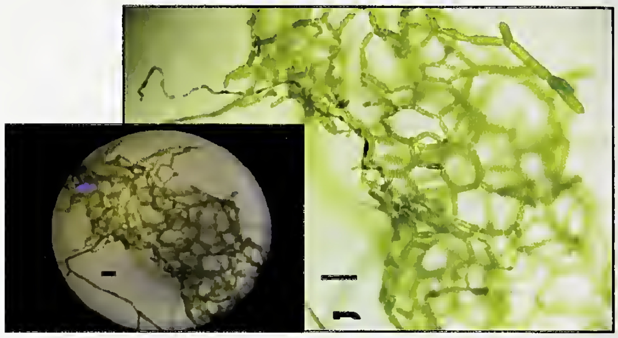

Fig. 1. *Hydrodictyon reticulatum*, Strathclyde Loch, September 2011. Scalebars 100 □m.

This species is known as a nuisance because it can clog waterways, smother aquatic plants and fauna and adversely impact boating, fishing, swimming and tourism. The spread of this alga is believed to be a response to elevated and extended summer water temperatures (John *et al.*, 1998). The species is confined to downstream sections of waterbodies, partially due to its nutrient requirements, and populations of the alga usually only become obvious in mid-summer, suggesting a need for high temperatures (Whitton, 2000).

It appears that the water-net has become widely distributed over the past two decades and is gradually beginning to colonise more northern waterbodies. Until 2011 the most northern documented records of the species were in Dumfries and Galloway, with other undocumented reports of the species as far north as Aberdeenshire. There are also anecdotal records of the species in Castle Semple Loch, Renfrewshire. The species is well documented in rivers in the Scottish Borders and northern England, especially the Tweed, Tyne, Wear and the Swale.

ACKNOWLEDGMENTS
Thanks to Alison Bell, John Clayton, Robin Guthrie (SEPA) and Professor Brian A. Whitton (Durham University) for their records of water-net distribution.

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Hoverfly species (Diptera, Syrphidae) collected near Rowardennan, Loch Lomondside, August, 2011

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A field outing to the Scottish Centre for Ecology and the Natural Environment (SCENE) at Rowardennan, Stirlingshire, followed the Sixth International Symposium on the Syrphidae (Diptera). It was the final day of this biennial meeting, held at the Hunterian Museum, University of Glasgow, during which 72 delegates had debated and discussed the systematics, ecology and biology of the hoverflies on a worldwide scale. The field outing on 8th August was essentially an opportunity to relax after three days of being indoors listening to lectures and viewing poster presentations on research in progress. A number of the delegates took the opportunity to record the hoverfly species that could be seen around the immediate environs of the SCENE field station buildings on the Ross peninsula. The following list is the product of this effort and is a good representation of the expected fauna. The sunny weather undoubtedly helped in producing a total of 63 species, a few of which are commented on individually in the following two paragraphs.

During the symposium a new edition of distribution maps for hoverflies in the United Kingdom was launched which contains new data on altitudinal and habitat preferences and phenology. Analyses of trends have been included for both recording effort and recent changes in species' ranges (Ball, *et al.*, 2011). This publication is used here to indicate species that deserve special mention for various reasons. Some are scarce in the north of Britain such as *Cheilosia proxima* and *C. vernalis*. Species that require good quality wooded habitat include *Arctophila superbiens*, *Ferdinandea cuprea* and *Xylota jakuatorum*. Although these three species have been recorded previously in the area it is good to know they are still resident. With similar habitat requirements, but developing as larvae in woodland fungi, are records of *Cheilosia longula* and *C. scutellata*. Generally scarce species of local note are *Didea fasciata*, *Dasysyrphus pinastri*, *Helophilus trivittatus*, *Meliscaeva compositorum*, *M. umbellatorum* and *Scaeva pyrastri*. One of the more interesting species is *Eriozona syrphoides* which became established in Britain about 40 years ago in association with spruce plantations. These trees support an aphid species, *Cinara piceae* (Panzer), that the larvae utilise as a food source. There are only thirteen other 10Km Ordnance Survey grid squares in Scotland where it has been seen since 2000 (Ball, *et al.*, 2011).

An outstanding addition to Scotland's fauna as a result of this meeting is *Ferdinandea ruficornis*. The latest distributional data show no known records north of Yorkshire (Ball, *et al.*, 2011). This species is regarded as rare or even endangered in many areas of mainland Europe. Like its more common sibling, *F. cuprea*, the larvae develop in sap in deciduous trees. Often, but not exclusively, these are oak trees in which this resource has been created by the tunnelling activities of the goat moth (*Cossus cossus* Linn.). The larvae of *F. ruficornis* have not been described (Rotheray, 1993) but are presumed to be very similar to *F. cuprea*. Goat moths are known from Central Scotland but are rare and have not been positively recorded on Lochlomondside (Knowler, 2010). Combined searching for the larvae of the moth and both species of *Ferdinandea* in the area around SCENE is an obvious strategy. More details of the Lochlomondside finding of *F. ruficornis* have been written up (Ricarte, *et al.*, 2011).

Species list in alphabetical order

Nomenclature follows Chandler (1998) with any changes or species added since then given in Ball et al. (2011). The asterisk * denotes records that were provided by Jeroen van Steenis just south of the field station on 2nd August, 2011, within the same NGR 10Km square as SCENE.

ACKNOWLEDGEMENTS

Thanks are due to Glasgow Natural History Society, British Entomological and Natural History Society, Dipterists Forum, Malloch Society, B&S Entomological Supplies and the Samuel Wendell Williston Diptera Research Fund (administered by the Smithsonian Institution, Washington DC, USA) as sponsors of the Symposium. Excellent hospitality was provided at SCENE, and particular thanks to Rona Brennan, bursar and provider of catering. The compiler of this list is grateful to all the participants for their efforts and company on the day.

Species	Recorder
Arctophila superbiens (Müller) *	(JvS)
Baccha elongata (Fabricius)	(MR)
Cheilosia antiqua (Meigen)	(ASs)
Cheilosia bergenstammi Becker	(EGH, JvS; WvS)
Cheliosia fraterna (Meigen)	(RM)
Cheilosia illustrata (Harris)	(JSetal)
Cheilosia longula (Zetterstedt)	(WvS)
Cheilosia proxima (Zetterstedt) *	(JvS)
Cheilosia scutellata (Fallén)	(JvS; WvS)
Cheilosia vernalis (Fallén)	(MR)
Chrysogaster solstitialis (Fallén)	(ASs)
Chrysotoxum arcuatum (Linnaeus)	(ASs; JSet al; WvS)
Chrysotoxum bicinctum (Linnaeus)	(ASs; JSet al; JvS)
Dasysyrphus albostriatus (Fallén)	(EGH; MM)
Dasysyrphus pinastri (De Geer)	(KW)
Dasysyrphus tricinctus (Fallén)	(EGH; JSet al; JvS)
Didea fasciata Macquart	(ASs)
Epistrophe grossulariae (Meigen)	(AR; EGH; KW; WvS)
Episyrphus balteatus (De Geer)	(ASs; EGH; JSet al; KW; RW; WvS; ZN)
Eriozona syrphoides (Fallén)	(ASs)
Eristalis abusivus Collin *	(JvS)
Eristalis interruptus (Poda)	(RM)
Eristalis intricarius (Linnaeus)	(NJ; JSet al)
Eristalis pertinax (Scopoli)	(AR; ASs; EGH; JSet al; KW; RW; WvS)
Eupeodes corollae (Fabricius)	(JSet al)
Ferdinandea cuprea (Scopoli)	(MR)
Ferdinandea ruficornis (Fabricius)	(JQ; determined by AR & ZN]
Helophilus pendulus (Linnaeus)	(JSetal; KW; WvS;)
Helophilus trivittatus (Fabricius)	(JSet al)
Leucozona lucorum (Linnaeus)	(JSet al; KW; RW; WvS)
Leucozona glaucia (Linnaeus)	(AR; ASs; JSet al; KW; WvS; ZN)
Melangyna compositarum (Verrall)	(AR; WvS; ZN)
Melangyna umbellatarum (Fabricius) *	(JvS) [a female]
Melanostoma mellinum (Linnaeus)	(ASs, JSet al; WvS; ZN)
Melanostoma scalare (Fabricius)	(ASs; JSet al; KW; RW; WvS; ZN)
Meliscaeva auricollis (Meigen)	(ASs; JvS; WvS)
Meliscaeva cinctella (Zetterstedt)	(AR; ASs; JSet al; KW; RW; WvS; ZN)
Myathropa florea (Linnaeus)	(AR; ASs; JSet al; JvS; WvS)
Neoascia podagarica (Fabricius)	(MR; JSet al)
Orthonevra nobilis (Fallén)	(RM)
Platycheirus albimanus (Fabricius)	(ASs; JSet al ; KW; JvS; WvS; ZN)
Platycheirus clypeatus (Meigen)	(ASs; JSet al; MR)
Platycheirus fulviventris (Macquart)	(RM)
Platycheirus granditarsis (Forster)	(JSet al)
Platycheirus nielseni Vockereth	(WvS)
Platycheirus occultus Goeldlin de T., et al.	(WvS)
Platycheirus peltatus (Meigen)	(ASs)
Rhingia campestris Meigen *	(JvS)
Riponnensia splendens (Meigen)	(AR; ZN)
Scaeva selenitica (Meigen)	(AR; WvS; ZN)
Sericomyia silentis (Harris)	(AR; ASs; JSet al; KW; RW; WvS; ZN)
Sphaerophoria interrupta (Fabricius) *	(JvS)
Sphegina clunipes (Fallén)	(JvS; MR)
Sphegina elegans Sehummel	(JvS; WvS)
Sphegina sibirica Stackelberg	(AR; ASs; JSet al; NJ; WvS; ZN)
Syritta pipiens (Linnaeus)	(JSet al)
Syrphus ribesii (Linnaeus)	(AR; ZN)
Syrphus torvus Osten Saeken	(WvS)
Syrphus vitripennis Meigen	(AR; KW; JSet al; WvS; ZN)
Volucella pellucens (Linnaeus)	(AS; ZN)
Xylota jakatorum Bagachanova	(WvS)
Xylota segnis (Linnaeus)	(AR; ASs; EGH; JSet al; KW; RW; WvS; ZN)
Xylota sylvarum (Linnaeus) *	(JvS)

Recorders

Antonio Ricarte (AR); Alan Stubbs (AS); Axel Ssymank (ASs); Geoff Hancock (EGH); Javier Quinto (JQ); Jeroen van Steenis (JvS); Menno Reemer (MR); Nigel Jones (NJ); John Smit, Maarten de Groot; Catalina Guitterez-Chacon, Jiri Hadrava (JH), Michael Mikal, working as a group (JSet al), Miriam Morales (MM); Roger Morris (RM); Richard Weddle (RW); Wouter van Steenis (WvS); Kenn Watt (KW); Zorika Nedeljkovic (ZN).

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First record of larval sea lamprey *Petromyzon marinus* L. in the Endrick Water, Loch Lomond

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Three lamprey species are known to occur in Scotland: European river *Lampetra fluviatilis* and brook lamprey *L planeri*, and the sea lamprey *Petromyzon marinus*. Although detailed records of their distribution remain scarce, lampreys have been sampled from 79 Scottish regions (ERA 2005). The sea lamprey is the rarest species in both records and surveys and has been recorded nationally in just 35 rivers, although their continuing presence in some is uncertain (ERA 2005).

The Endrick Water drains the South East catchment of Loch Lomond into its south basin. The river contains scientifically important populations of brook and river lamprey, and has been designated a Special Area of Conservation (SAC) and Site of Special Scientific Interest (SSSI) as a result (Bond 2003; Hume 2011). Although several lamprey surveys have been conducted in recent years (Maitland et al. 1994; Gardiner et al. 1995; Gardiner & Stewart 1997, 1999; Forth Fisheries Foundation 2004; Hume 2011; Watt et al. 2011) adult sea lamprey have been recorded only very occasionally in the Endrick Water, and they have not been observed since the 1960s (Hunter et al. 1959; Maitland 1966). Spawning is believed to be restricted to the efferent River Leven between the barrage (NS 393 894) and footbridge (NS 394 793) in Balloch (Maitland et al. 1994; Gardiner et al. 1995). Despite extensive sampling of larval habitat around the Loch Lomond basin in recent years, sea lamprey ammocoetes have until now only been recorded in the River Leven.

On March 21st 2012 a single sea lamprey ammocoete was collected immediately downstream of Drymen Bridge on the Endrick Water (NS 473 874) in static traps designed to capture adult lampreys on their upstream spawning migration. This individual measured 151 mm in total length and was 4.6 g wet weight. Positive identification as *Petromyzon* as opposed to *Lampetra spp.* was confirmed from the following meristic and morphometric characteristics (Fig. 1): trunk myomeres 71 (*P. marinus* 67-74; *Lampetra spp.* 58-64), oral hood fully pigmented (*Lampetra spp.* upper/lower lip unpigmented), caudal fin spade-like (*Lampetra spp.* typically rounded), robust head region (*Lampetra spp.* distinct pre-nostril region) (Renaud 2011). Sea lamprey larval duration is typically five years, although it can be as long as 19 years as growth rates vary enormously, so an accurate age estimate of just one individual is fraught with uncertainty. Based on typical values from other U.K. populations this individual is likely to be 3-5 years old, indicating that spawning took place in the Endrick Water at sometime between May/June 2007-2009 (Hardisty 1969; Bird et al. 1994).

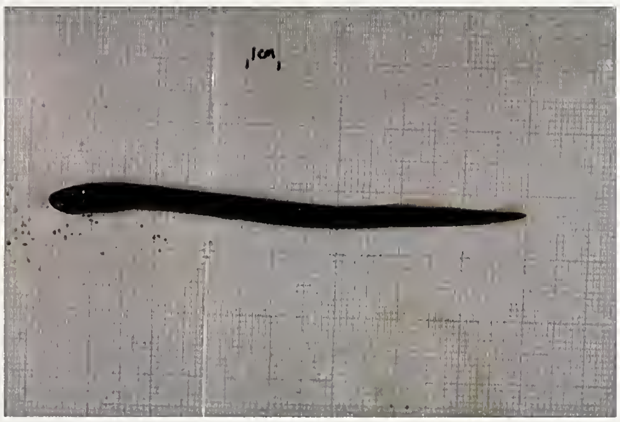

Fig. 1. *P. marinus* ammocoete

Throughout Scotland larval *Petromyzon* are recorded in very low densities compared with *Lampetra spp.,* even in rivers known to contain strong adult spawning populations (APEM 2004; ERA 2004; Watt et al. 2008). There remains the possibility that sea lamprey spawn in the Endrick Water in small numbers, but; that adults are not detected because trapping methodology excludes the larger body size of mature sea lamprey, and sea lamprey ammocoetes are not detected during routine surveys due to their inherent scarcity. Currently, the Endrick Water is a stronghold for lamprey in Scotland, with both *L. fluviatilis* and *L. planeri* populations being of international conservation importance (Bond 2003). If indeed this isolated record of larval *P. marinus* represents the first indication that

the species now maintains a spawning population within the Endrick Water, there is an implication that the conservation strategy for this river should be modified to include sea lamprey as a qualifying feature of the SAC.

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A record of the aurochs, *Bos primigenius*, from Morayshire

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In May 2004 two horn cores attached to the frontal bone of a skull (Fig. 1) were discovered at the bottom of the main drainage ditch in the northeast corner of Ardgye Farm, three miles west of Elgin in Morayshire (Grid Reference NJ155638). These horn cores were recovered by Martin Bridges, the Moray Estates farm manager, and were sent to the National Museums Scotland for identification and conservation. Comparison with specimens in the NMS collection confirmed that the horn cores were from an aurochs, *Bos primigenius*. From their size and shape the horn cores were probably from a male. The left horn core measures 700 mm on the outside of the curve and 550 cm on the inside of the curve, whereas the right horn core measures 670 mm on the outside curve and 570 mm on the inside curve. The basal circumferences of the horn cores are 350 mm (right) and 340 mm (left). A bone sample was sent to SUERC, East Kilbride, where it yielded a radiocarbon date of 9690 ± 35 BP and a calibrated date of 11,120-11,260 BP (SUERC-20754).
Calendar dates are increasingly underestimated by increasingly earlier radiocarbon dates (Lowe and Walker, 1997). This is because the amount of radiocarbon in the atmosphere has not been constant over time. Uncalibrated dates can be corrected using a calibration curve that is derived from samples that have been dated independently with other methods such as uranium time series, dendrochronology, varves and deep ocean sediment cores.
The aurochs is widely recorded in Scotland and the rest of Britain. Yalden (1999) records 30 Scottish sites ranging from Orkney to Berwick in the south east and New Galloway in the south west. However, most records are from the Borders with a few in Perthshire. Therefore, these horn cores represent one of the most northerly records in Scotland.

There are few radiocarbon dates for aurochs in Scotland. Kitchener & Bonsall (1999) give five dates,

ranging from 9170 ± 70 BP (10,350-9,980 Cal BP age – AA18516) for a skull from Newburgh, Fife to 3315 ± 55 bp (3690-3390 cal BP – AA-18517) for skull from Galloway. The latter is one of the most recent dates for Britain, suggesting that it survived until at least the early Bronze Age in Scotland (Yalden & Kitchener, 2008). A similar date was recorded for a skeleton from Charterhouse Warren Farm, Somerset (Burleigh & Clutton-Brock, 1977). However, the Ardgye Farm specimen is the oldest recorded post-glacial date for an aurochs in Scotland, and demonstrates that this species was an early post-glacial coloniser.

a.

b.

Fig. 1. Dorsal (a.) and ventral (b.) views of the horn cores of an aurochs, Bos primigenius, from Ardgye Farm, Morayshire (Neil McLean, National Museums Scotland).

The horn cores are available for viewing by appointment at Moray Estates (013096 72213 or admin@medeo.co.uk).

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The rare green alga *Pediastrum privum* (Chlorophyta, Sphaeropleales) in a Scottish kettle loch: new to British freshwaters

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Pediastrum is a widely-distributed genus of green alga characteristically consisting of disc-shaped colonies or 'coenobia', assembled from at least four inter-connecting cells (Komárek & Jankovská, 2001).

Many species belonging to the genus are common constituents of lake phytoplankton communities, though *Pediastrum privum* (Printz) Hegewald [=*Stauridium privum* (Printz) Hegewald in Buchheim *et al.*, 2005] is notably rare (Komárek & Jankovská, 2001; Tsarenko & John, 2011). There appear to be no published records from Britain. Sporadic lake phytoplankton and sub-fossil sediment finds from Europe, reflect a sparse scattering of *Pediastrum privum*, confined mostly to temperate and sub-arctic latitudes of the northern hemisphere (Hegewald & Schnepf, 1979; Komárek & Jankovská, 2001; Geriš, 2004; Kowalska & Wołowksi, 2010). By comparison, the close phylogenetic relative *Pediastrum tetras* (Ehrenberg) Ralfs [=*Stauridium tetras* (Ehrenberg) Hegewald in Buchheim *et al.*, 2005] displays a cosmopolitan distribution (Komárek & Jankovská, 2001).

Freshwater phytoplankton communities are important indicators of the biointegrity of standing waters and are therefore used by the Scottish Environment Protection Agency (SEPA) to assess the ecological status of around 80 freshwater lochs in Scotland. Phytoplankton samples are collected at varying frequencies, but at a minimum are taken three times a year between July and September. Sub-samples of phytoplankton (preserved in Lugol's iodine) are examined using an inverted microscope and analysed according to standard

procedures with counts of approximately 400 individuals (Brierley *et al.*, 2007; CEN, 2004 & 2008).

Low abundances (typically 1-5 coenobia, comprising both four- and eight-cells, per 100 ml sub-sample) of *Pediastrum privum* were found in phytoplankton samples collected from Loch Kinord during 2009–2011. Loch Kinord is a small kettle lake located in Aberdeenshire, Scotland (NGR: NO 44150 99388). The loch, formed by glacial retreat approximately 10,000 years ago, has an area of c. 0.8 km^2, is shallow (mean depth <2 m) and is characterized by relatively low alkalinity (annual mean 10.7 mg L^{-1} as $CaCO_3$ over 2009-11) and mesotrophic water chemistry (annual mean total phosphorus (TP) concentration 19.9 µg L^{-1} over 2009-11). A palaeolimnological study using fossil diatoms implied that eutrophication has driven water quality in Loch Kinord slightly away from its reference state (Bennion *et al.*, 2004).

Pediastrum privum has appeared consistently in the phytoplankton community of Loch Kinord since 2009. This is the first known documented record of *Pediastrum privum* in British freshwaters. Previously, this uncommon species may have gone unnoticed or been misidentified due to its inconspicuous size and general unfamiliarity to UK taxonomists. The coenobia of *Pediastrum privum* (Figs 1a-d) morphologically resemble *Pediastrum tetras* (Figs 2a-d), in terms of their relatively small diameter (usually 15–25 µm). However, it is possible to separate the two species by comparison of the outer cell wall structure, which is weakly concave (central depression) in *P. privum* and distinctly notched (central incision) in *P. tetras* (Komárek & Jankovská, 2001; Kowalska & Wołowksi, 2010; Tsarenko & John, 2011).

Pediastrum privum has been recorded mostly from European waterbodies including Norway (Printz, 1914), Finland (Hegewald & Schnepf, 1979), Poland (Pełechaty *et al.*, 2007; Kowalska & Wołowksi, 2010), Russia (Jankovská & Komárek, 2000), Slovakia (Hindák & Hindáková, 2008), and the Czech Republic (Geriš, 2004), though the WISER phytoplankton database (www.wiser.eu) may also contain previously undocumented localities. Other reports exist from the USA (Smith, 1920; Prescott, 1962), as well as more recently from Korea (An *et al.*, 1999), Spain (Negro *et al.*, 2000) and Canada (Hindák & Hindáková, 2008). Collectively, observations suggest that *Pediastrum privum* occurs discretely in oligotrophic and/or dystrophic freshwaters (Jankovská & Komárek, 2000; Komárek & Jankovská, 2001). However, some accounts suggest it is also capable of occupying nutrient-enriched habitats (An *et al.*, 1999), typically associated with *P. tetras* (Komárek & Jankovská, 2001), which makes its restricted distribution difficult to explain (Kowalska & Wołowksi, 2010). Morphological plasticity (variation between the 4- and 8-celled life cycle stages) has been related to environmental nutrient concentrations or zooplankton predation in *Pediastrum tetras* (Rojo *et al.*, 2008), and though fully described (Hegewald & Jeon, 2000) is as yet inadequately understood for *P. privum*. More research is required to establish the ecological requirements of *Pediastrum privum* and the reasons for its apparent rarity.

ACKNOWLEDGEMENTS

Thanks especially to Prof David John (Natural History Museum London) and Prof Brian Whitton (University of Durham) for formally verifying the identity of *Pediastrum privum*. We are grateful to Dr Elizabeth Haworth (Freshwater Biological Association) for confirming that no UK records of *P. privum* pre-existed in the Fritsch Collection (documented only from Norway, Europe and North America). We are also appreciative to Dr Kevin Murphy (University of Glasgow) for commenting on an earlier version of the manuscript.

Fig. 1a. Photo-micrograph of *Pediastrum privum* 4-celled coenobium (x630 magnification) preserved in Lugol's Iodine.

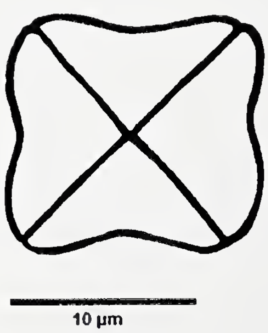

Fig. 1b. Illustration of *Pediastrum privum* 4-celled coenobium.

Fig. 1c. Photo-micrograph of *Pediastrum privum* 8-celled coenobium (x630 magnification) preserved in Lugol's Iodine.

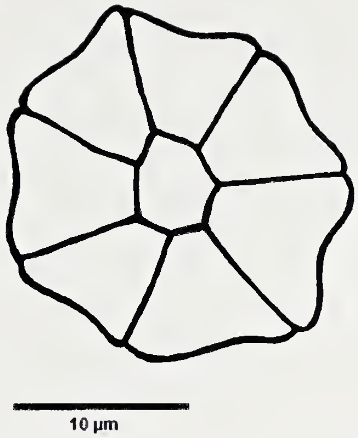

Fig. 1d. Illustration of *Pediastrum privum* 8-celled coenobium.

Fig. 2a. Photo-micrograph of *Pediastrum tetras* 4-celled coenobium (x630 magnification) preserved in Lugol's Iodine.

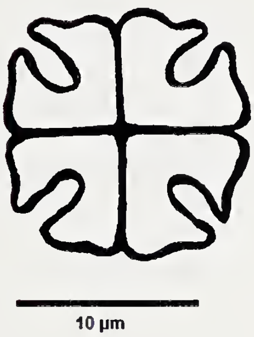

Fig. 2b. Illustration of *Pediastrum tetras* 4-celled coenobium.

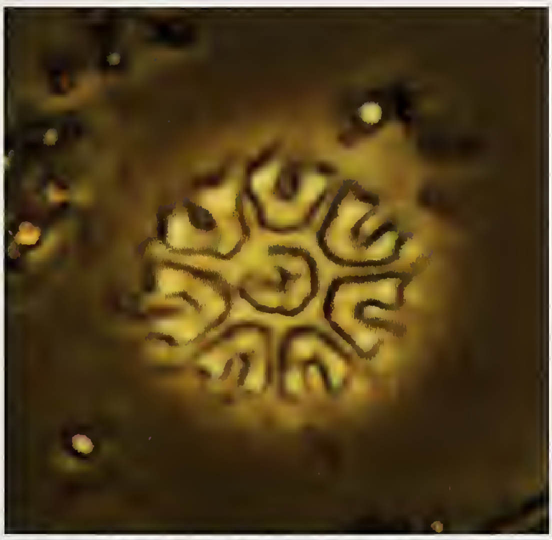

Fig. 2c. Photo-micrograph of *Pediastrum tetras* 8-celled coenobium (x630 magnification). preserved in Lugol's Iodine.

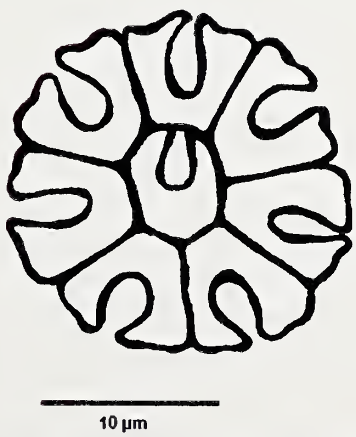

Fig. 2d. Illustration of *Pediastrum tetras* 8-celled coenobium.

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First records of the pygmy sperm whale, *Kogia breviceps*, in Scotland

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The pygmy sperm whale, *Kogia breviceps*, is a poorly known cetacean species, which has been recorded rarely in the British Isles (Leaper and Evans, 2008). It is an oceanic species that inhabits tropical to warmer temperate waters worldwide (Caldwell and Caldwell, 1989). In the North Atlantic it strands reasonably commonly on the coast of the southeast USA (125 strandings between Puerto Rico and Maine 1999-2003 (Waring *et al.*, 2005) as far north as Canada, and in the eastern Atlantic it has been recorded from the Bay of Biscay, stranding from Portugal to the western coast of France with fewer records from the Netherlands and the British Isles (Evans, 1991; Santos *et al.*, 2006). Here we record the first strandings of pygmy sperm whales in Scotland.

Pygmy sperm whales are usually found in small groups of up to six individuals, but more often they are seen alone or in pairs; strandings are most often large males, or mothers and their calves of varying ages, or single females that have recently given birth (Caldwell and Caldwell, 1989; McAlpine, 2002). They feed mostly on

squid (e.g., *Brachioteuthis, Chiroteuthis, Chtenopteryx, Galiteuthis, Gonatus, Histioteuthis, Lepidoteuthis, Loligo, Mastiogoteuthis, Ommastrephes, Pholidoteuthis, Taonius, Teuthhowenia, Todarodes*), octopus (*Eledona* sp., *Octopoteuthis*) and sepiolids (*Sepiola, Rossia*), and also some deep-water fish (e.g., *Micromesistius* spp., *Chauliodus sloani*) and crustaceans (e.g., swimming crabs, *Polybius henslowi*, mysids, *Gnathophausia* sp.) at or near the bottom of the sea at a depth of 500-1000 metres on the deep shelf or slope, although dives may be less than this, because both squid and fish commonly migrate towards the surface at night (Caldwell and Caldwell, 1989; Evans, 1991; Santos *et al.*, 2006). Females and their well-grown calves may feed on coastal cephalopod species, where available.

Pygmy sperm whales grow to about 3.8 m long and weigh up to 450 kg (Caldwell and Caldwell, 1989; McAlpine, 2002). In recent strandings in Spain and France body length (from tip of upper jaw to fluke notch in a straight line) ranged from 1.6 m to 2.75 m for males (n=9), and 1.47 m to 3.24 m in females (n=8) (Santos *et al.*, 2006). Females reach sexual maturity at about 2.6 metres in length and give birth to a calf of about 1.2 m after an estimated gestation of about nine months (Caldwell and Caldwell, 1989; McAlpine, 2002).

Pygmy sperm whales strand rarely in the British Isles. Since formal records began in 1913, there were only eight strandings on the British coast from 1980 to 2006, mostly in southwest England and Wales (Sabin *et al.*, 2003). In 1999 an adult female and a calf of unknown sex stranded at Loch Ryan, Stranraer, Dumfries and Galloway. Measurements and other details of these specimens are given in Table 1. The adult female was in the early stages of pregnancy with a male foetus 25 cm long. The dead calf floated away, but was subsequently recovered 11 days later after being buried at a landfill site, by which time it was too decomposed to determine its sex. Analysis of stomach contents of the mother and calf have confirmed that their diet comprised mainly oceanic squid, mainly three species of *Histioteuthis*, but also 11 other cephalopod species from a total of nine families, as well as unidentified fish and crustaceans (shrimps) (Santos *et al.*, 2006). The skeletons of the female and calf are in the collections of the National Museums Scotland (NMS.Z.1999.264.1-2) and the male foetus is preserved intact in spirit (NMS.Z.1999.264.3). A cast of the head of the adult female was also taken for future reference. Measurements and characteristics of the skull and mandible of the adult female (NMS.Z.1999.264.1), following Ross (1984), are given in Table 1 in comparison with similar data from a specimen that stranded in Ireland, which is also in NMS's collection. Both specimens have 13 tooth alveoli on each side of the mandible, which falls within the reported range of 11-17 (Best, 2007). There were no teeth in the maxillae of either specimen.

There were no further records in Scotland until 2007 when one or two pygmy sperm whales were reported from Shetland (Harvey *et al.*, 2011). An animal was seen and photographed off the west mainland of Shetland at Aith on 14th October 2007 (Irene Gray pers. comm.), although two animals of different sizes were seen together at Olnafirth, Delting on 15th October (Gibby Fraser, pers. comm.). On 17th October a pygmy sperm whale was photographed at Busta Voe (HU357679) (Roger Tait, pers. comm.). Later the same day a young animal was stranded alive at Brae. Therefore, the two animals seen at Olnafirth may have been an adult female and a well-grown calf, which eventually stranded and was euthanased by a vet.
The stranded animal was initially identified as an Atlantic white-sided dolphin, *Leucopleurus acutus*, but by the time it had been correctly identified this specimen had been irretrievably buried at a landfill site in Lerwick.

No.	Sex	Age	Length (m)	Date	Location	SW no	Comments
1.	F	Adult	2.68	18.10.99	Loch Ryan, Stranraer, Dumfries and Galloway	SW1999/185d.1	Pregnant with 25-cm-long foetus
2.	U	Juvenile	2.08	18.10.99	Loch Ryan, Stranraer, Dumfries and Galloway	SW1999/185d.2	Refloated and restranded 11 days later
3.	U	Juvenile	c.2.1-2.4	17.10.07	Brae,Shetland (HU355680)	SW2007/207A	Specimen lost at landfill site
4.	M	Adult	2.11	6.10.11	Easdale, Seil, Argyll (NM75231686)	SW2011/459	

Table 1. Strandings of pygmy sperm whales, *Kogia breviceps*, in Scotland.

Fortunately, digital photographs were taken prior to burial, which allowed correct identification (Fig. 1) (Ellis Nicolson, pers. comm.), but the loss of this important specimen demonstrates the importance of ensuring that identification is confirmed before an animal is disposed of. Cuts on the animal photographed by Roger Tait, including a distinctive one on the left side of the spermaceti organ, appear to match those on the stranded animal (Fig. 1). However, a distinctive cut on the upper left hand side in front of the dorsal fin, which can be seen in the photographs by Irene Gray and Roger Tait, is apparently absent from the stranded animal and the cut on the spermaceti organ appears to be longer in the live animal. Closer examination of Roger Tait's photographs reveals two whale barnacles (Family Coronulidae) on the upper left side of the tail stock (Fig. 2 b,c), which appear to be absent from the stranded animal (Fig. 2 a). As far as we know this is the first record of whale barnacles on this species and genus, but unfortunately the quality of the photograph does not allow a more specific identification. Roger Tait estimated that the live animal was perhaps 10 feet (3 metres) long, whereas the stranded animal, compared with the wheel barrow, is probably 2.1-2.4 metres long. Although uncertain, evidence from these photographs supports the presence of two animals in Shetland and that it was the younger of these that stranded.

a.

b.

Fig. 1. Photographs of pygmy sperm whale from Shetland, 2007. a. Live animal Busta Voe, 17 October 2007 (Roger Tait), b. stranded animal prior to disposal on 17th October 2007 (Ellis Nicolson). Skin lesion present in the living animal (a., arrow) is not apparent in stranded one.

a.

b.

c.

Fig. 2. Photographs of pygmy sperm whale from Shetland. a. No whale barnacles are apparently present on the tail stock of the stranded animal from Shetland, but are visible on the live swimming animal (c; arrow). See close up in b.

On 6th October 2011 a juvenile male pygmy sperm whale stranded at Easdale, Seil, Argyll (Table 1). The skeleton is preserved at NMS (register no. NMS.Z.2011.97.192) and measurements of the skull are given in Table 2. A small whale barnacle was observed on the right side of the dorsal fin of this

specimen, but was not recovered. Stomach contents included fish eye lenses, otoliths, squid beaks and small fragments of squid tissue, showing that it had fed recently, but these have not yet been identified.

	Measurement (m)	Adult female Stranraer, Dumfries and Galloway, 18.10.99 NMS.Z.1999.264.1	Juvenile male Easdale, Seil, Argyll 6.10.11 NMS.Z.2011.97.192	Subadult male Beartragh Bay, Co. Mayo, Ireland, 19.6.99 NMS.Z.2001.108.28
1	Total (condylobasal) length	372.0	291.0	307.5
2	Rostrum length	192.3	142.3	156.6
3	Basal width of rostrum	158.1	140.3	130.9
4	Width of rostrum at its midlength	103.8	97.0	96.5
5	Breadth across pre-orbital angles of supra-orbital processes	302.2	263.3/267.8	264.4
6	Breadth across post-orbital processes of frontals	324.0	269.8	276.6
7	Breadth of skull across zygomatic processes of squamosals	310.0	267.4	262.3
8	Height of vertex	265.2	201.9	215.9
9	Width of vertex	49.9	20.9	25.2
10	Width of supra-occipital at narrowest part between posterior margins of temporal fossae	236.0	194.2	196.8
11	Tip rostrum to anterior border of left naris	187.1	137.9	145.7
12	Height of ventral border of foramen magnum	119.9	95.0	99.8
13	Length maxillary tooth groove, right	153.6	60.0	103.0
14	Length maxillary tooth groove, left	156.2	(est.) 52.5	116.7
15	Width between outer margins of occipital condyles	81.3	66.5	65.2
16	Tip of rostrum to hind margin of pterygoids near the midline	224.5	173.8	191.1
17	Length of mandible, left side	(est.) 325.0	(est.) 270.6	265.6
18	Number of alveoli, left	13	11	13
19	Number of alveoli, right	13	11	13
20	Height of mandible at coronoid process, left side	92.9	(est.) 74.3	74.4
21	Length of mandibular symphysis, left side	(est.) 68.2	(est.) 59.3	55.1
22	Length of tooth row, lower left	(est) 132.6	(est.) 90.4	114.3
23	Length of tooth row, lower right	(est.) 138.5	(est.) 91.3	(est.) 119.0
24	Height dorsal border of foramen magnum to vertex	133.5	117.0	121.0
25	Length, anterior margin mesorostral ossification to anterior border of left naris	28.9	12.5	24.0

Table 2. Measurements of the skulls of an adult female pygmy sperm whale stranded at Stranraer, a juvenile male from Argyll and a subadult male from Co. Mayo, Ireland. All specimens in National Museums Scotland. Measurements follow Ross (1984).

These are the first records and strandings of pygmy sperm whale in Scotland and have coincided with an increase of other warm water cetacean stranding on the Scottish coast since the late 1980s, including striped dolphin, *Stenella coeruleoalba*, and Fraser's dolphin, *Lagenodelphis hosei* (Reid *et al.*, 1996; Bones *et al.*, 1998). Analyses of strandings patterns in Scotland suggest that these warm-water species may be moving further north, owing to warmer sea temperatures as a result of global climate change (MacCleod *et al.*, 2005). Interestingly, both records appear to be of mothers and a calf at the same time of the year, which is consistent with strandings elsewhere. Taking the foetus length of 25cm as about two months into gestation (i.e. about 20% of birth length), indicates conception occurred in about August, suggesting the older calf was about five to six months old. There is a risk that strandings of pygmy sperm whales might be confused with large porpoises, but it will be interesting to see if the trend continues with increasing records of this species as we have seen already with the striped dolphin.

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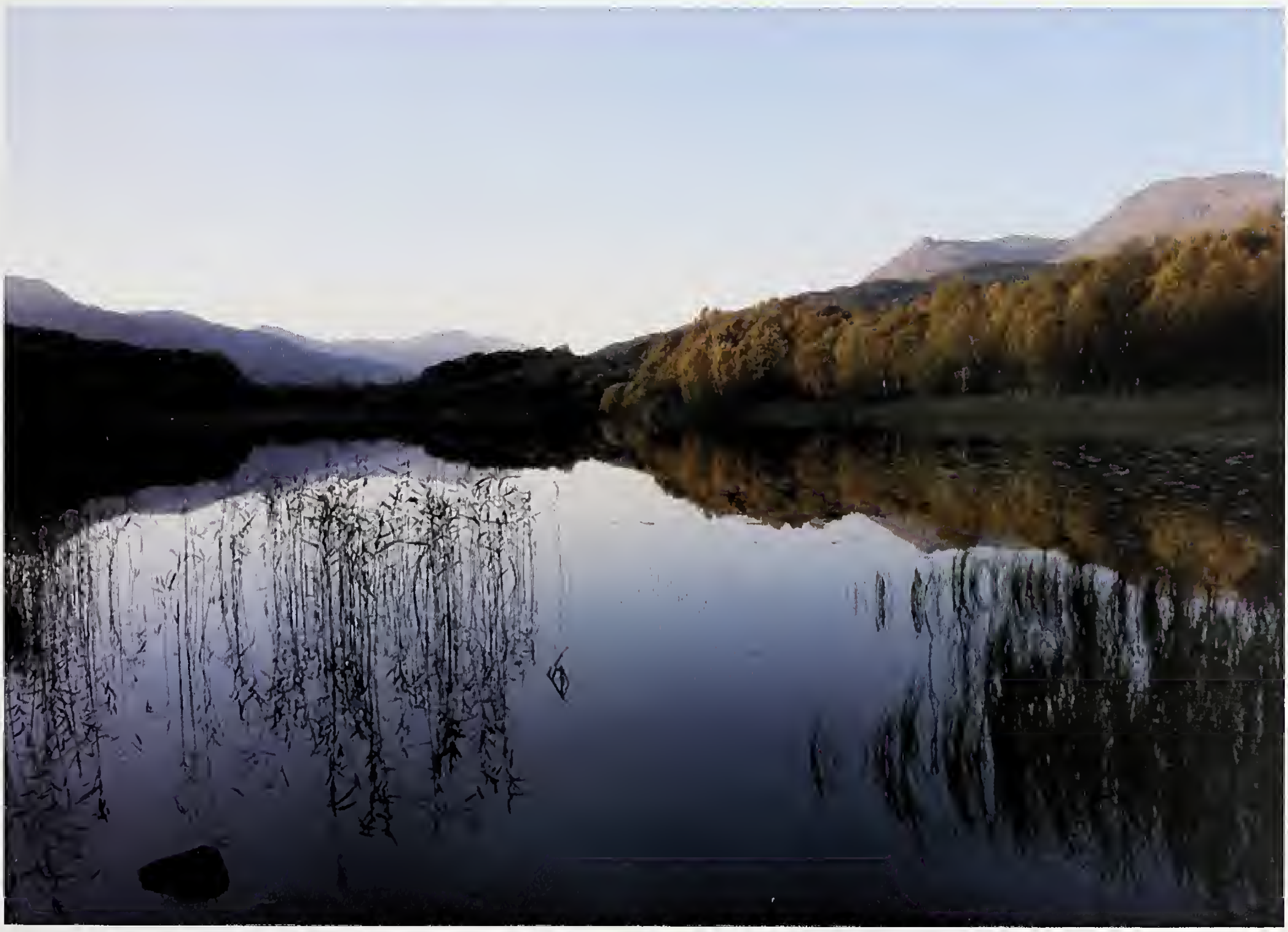
Scottish Centre for Ecology and the Natural Environment and Glasgow Natural History Society Photographic Competition 2012

First Prize. Male palmate newt (*Lissotriton helveticus*), Ben Lomond April 2011, Anna Muir



Second prize The Dubh Lochan, Loch Lomondside, John Hume

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OBITUARIES

OBITUARY

Norman Roy Grist, 1918 -2010

Norman Roy Grist was born in Doncaster on 9th March 1918. His inquisitive mind and love of nature was evident at an early age. Among his childhood possessions were astronomy books and a telescope. When he moved to Glasgow as a schoolboy he lived in Shawlands where he put the garden to good use; he set up a den with his Meccano set, created a museum with a Great Diving Beetle as a central exhibit, and made an aquarium in a basin with snails, beetles and tadpoles.

At Shawlands Academy he excelled academically, especially in Science. He expanded his love of music, made many friends and cycled through the Highlands. He became Dux of the school, and gained a Bursary to Glasgow University where he studied for a combined science and medical career. As a student at the outbreak of war, Roy volunteered to help man a First Aid Post in Pollokshaws Baths. He graduated BSc in 1939 and MB, ChB in 1942.

In 1941 he met his future wife Mary. During many tennis matches, films, theatre visits and dances, they got to know each other, and they were married in 1942. Wartime duties and university studies kept them apart for much of the war.

After completing his medical studies, Roy embarked on military training in Leeds, which led to his involvement in the D-Day landings as a captain in the Royal Medical Corps. He went from the beaches of Normandy through Northern France, Belgium, Holland and through to the Rhine, enduring many hardships of war, and later went on to serve in Palestine.

Returning to Glasgow in 1946 he was reunited with Mary, now discharged from the WAAF, and started what became an internationally renowned medical career. His specialism was infectious diseases, at which he excelled. He pioneered research into influenza at Knightswood and Ruchill Hospitals in Glasgow which helped to improve the lives of many Glaswegians. While his reputation spread internationally he continued with his love of natural history; for example taking great delight in pointing out Kestrels nesting in the tower of Ruchill Hospital.

By 1952 Roy was a lecturer in virus diseases, and became head of the Regional Virus Laboratory at Ruchill from 1958 to 1983. He became closely involved with the World Health Organisation, travelling abroad giving lectures, some of them in his fluent French. He became Professor of Infectious Diseases at Glasgow University in the mid 1960s. Meanwhile, previous collaboration with other leading workers in the field led to the formation in 1967 of the Communicable Diseases (Scotland) Unit, recognised as a prime example of a national surveillance centre. He was honoured by the Spanish Government for his meticulous study (with others) of the Legionnaire's Disease outbreak in Benidorm in 1973.

He was part of the virology initiative in creating the first virus laboratory, was a founder member of the first university virology department in 1962, and advised the Western Regional Hospital Board from 1960 to 1974. He was a member of the Expert Advisory Panel on Virus Diseases to the WHO from 1967 to 2001. He developed a diagnostic and epidemiological service in smallpox and polio.

Roy retired in 1983 but never stopped inquiring and learning. Roy's life with Mary was central; they shared many interests and were always together. They continued various activities into their eighties, including their cottage in Arran which they shared with Mary's brother Angus and his family. For 40 years they lived in their home at Sydenham Court, where they enjoyed working in the garden and watching wildlife.

They were both keen members of the Glasgow Natural History Society and this undoubtedly played a big part in their lives. Roy was President of the GNHS from 1993 to 1996. His almost obsessional interest in natural history was demonstrated at a medical colleague's retirement when he was wearing his slug tie and talked about slugs in his garage from the starter right through to the coffee with no problem at all. His passion for wildlife and knowledge generally was amazing. He edited the GNHS newsletter for many years until 2004, when he passed it over in very good shape to his successor.

Roy and Mary were very sociable, outgoing people, and it was with great sadness to Roy that Mary passed away in 2009. Roy's life was appreciated greatly by many people. He lived a good life and the world was a better place for his contribution to it. Roy spent his final year in the Red Cross House at Erskine Care Home. Even there he had a computer set up with an

internet connection and would still send contributions for the GNHS newsletter!

Roy died on June 7th, 2010 at the age of 92.

David Palmar

OBITUARY

Agnes Walker March 1930 – August 2011

Agnes had many and varied interests, and as a result had acquired friends from a variety of backgrounds. She really loved people and greeted acquaintances so enthusiastically whenever she met them.

Agnes was the eldest daughter of James and Elizabeth McDonald. She was educated at Hutchesons' Girls Grammar School, where she was the first science dux. Having also passed her music grades to a high standard she chose science as her future. Her studies at Glasgow University were interrupted for a year when she contracted TB, so she settled for an ordinary B Sc. Her first post was at the National Engineering Laboratory in East Kilbride. She gave up work to marry Norman Walker and raise a family - a daughter followed by three sons. She spent holidays at Norman's second home, Abernethy House, which later became a Christian Outdoor Centre. While there she made contact with the outdoor centre at Glenmore Lodge, and used to lead students from Moray House on expeditions to the Cairngorms to study the plant life.

Her determination to continue her academic studies led to the breakdown of her marriage. She worked in the Botany Department of Glasgow University with Dr Jim Dickson researching the ancient history of bogs and lochs using pollen identification, and gained an M Sc. Her PhD was in a different field and at Belvidere Hospital - the reactions of tumours (in mice) to hypothermia.

The post of Assistant Keeper of Natural History at Kelvingrove was an ideal one for Agnes. She focussed on the botanical side, and set up many exhibitions, one of the most important being that on the Scottish Thistle. For this she drove to Blair Castle and was allowed to transport in the boot of her car a valuable historic painting in which the thistle is depieted. During this time she also gave lectures on Botany and Fungi for the adult education department of Glasgow University. She joined the Glasgow Natural History Society in 1969 and was a member of Council from 1990 – 1992. At the time of the Glasgow Garden Festival, Agnes designed a poster on the Classification of Flowering Plants, which was published by the Natural History Museum in London.

Having been a member of the Botanical Society of the British Isles for some years, in 1989 she was appointed recorder for vc 103, Mid Ebudes, which comprises the islands of Mull, Coll and Tiree. She organised several recording meetings in these islands, which were attended by many expert botanists. On Tiree the outdoor centre which she had hoped to use was not ready, but Agnes organised a stone barn beside the guest house to be supplied with electricity and tables set up with microscopes to help identification of plants in the evening. On the last night, a ceilidh was held in the same barn.

After she retired from her job at Kelvingrove, Agnes took a course on computing, and also acquired a knowledge of how to computerise music. Her technical expertise enabled her to work with Dr Kenneth Elliot who had been for many years restoring the works of Robert Carver, Scotland's greatest 16th Cent. Composer. With the help of others in GU music department , he sueceeded in his ambition and the complete works were published and are being widely performed.

Through friendship with Mrs Dudgeon of Helmsdale who started the herb garden at Timespan Museum in Helmsdale, Agnes developed a great interest in herbs. She researched the use of herbs in Scotland, for both medicinal and culinary purposes. This resulted in the beautifully illustrated book a "Garden of Herbs". The illustrations were from Nicolas Culpepper's Herbal (no copyright needed) and some by her friend Anita Pearman. She gave a talk on this subject in the Royal College of Physicians and Surgeons of Glasgow and was shown a notebook of herbal remedies from 18th Cent. Scotland. She had transcribed this for issue as a CD when she suffered the severe stroke which put an end to her many activities.

Edna Stewart

BOOK REVIEWS

Blumea – Biodiversity, Evolution and Biogeography of Plants

Proeeedings of the 7th Flora Malesiana Symposium

National Herbarium of the Netherlands. 2009. c.300 pages, colour and black & white photographs, softback. ISSN 0006-5196, £102.

"Flora Malesiana" is a forum for the entire field of Malesian botany, faeilitating the exchange of information and producing a variety of output formats ranging from identification lists and specimen databases to monographs, biodiversity assessments and analysis of spatial patterns of biodiversity. It is hoped that after the 2007 Symposium the Flora Malesiana Project will turn into one of the first running mega flora projects to become truly web-based and interactive. This publication consists of the presentations given at the 2007 Symposium.

Malesiana is recognised as a floristic region. It includes the South Malay peninsula, Sumatra, Java, Borneo and Sulawesi and islands to the east as far as New Guinea. Divisions within the region correspond to the geological history. The most famous division is in a western and eastern sub-region, separated by Wallace's Line. Wallace found a distinct boundary between the Southeast Asian- and the New Guinea-Australian fauna, located east of the Philippines, between Borneo and Sulawesi and finally between Bali and Lombok. (Wallace was the British naturalist who proposed the Theory of Evolution simultaneously with Darwin.)

Although this publication is directed towards professionals, the general reader can find much of interest. There is an amazing series of scanning electron micrographs of pollen grains of 21 Phyllanthus species found in the Philippines as an aid to classification.

There are wonderful photographs of flowers of the parasitic Rafflesia - some species of which include the world's largest flowers, up to 1.5 m. diameter. New species are still being discovered, yet the lowland tropical rain forest which is an important habitat for many species of Rafflesia is one of the most threatened forest types in the Philippines and other tropical areas. Even in protected areas such as the Mt. Kilanglad Range Natural Park, unsustainable ecotourism activities can damage Rafflesia plants and the roots of their host vines. The flowers of some montane species have been known to be brought down from the mountains for visitors to see – greatly endangering the survival of these populations.

Two botanists, C. Pendry and M. Watson based at the RBG Edinburgh have been working on the Flora of Nepal. They have a paper in which they argue that there is a significant overlap of plant species and genera between Nepal and Malesia, and that it would be advantageous to workers on the Floras of each region to cooperate with each other, allowing transfer of expertise and speeding up the preparation of accounts.

Throughout this publication and especially under the heading of Conservation Studies, one is aware of the rate at which the tropical rain forests are disappearing due to logging and mining. As more information on the flora of this endangered habitat is gathered, perhaps there will be more effort to save what is left.

Edna Stewart

Mayfly larvae (Ephemeroptera) of Britian and Ireland: keys and a review of their ecology

J.M. Elliott and U.H.Humpesch

Freshwater Biological Association Scientific Publication No. 66, Ambleside, Cumbria. 152 pages, soft back illustrated with colour photographs, diagrams and drawings. ISBN 978-0-900386-78-7, £27.00.

From the FBA stable comes another publication which is only partly an update of an earlier key on mayfly larvae. The other part is a comprehensive account of their ecology with a massive bibliography of primary sources. Added information is given on Red Data Book status and a list of anglers' names. A pictorial key to families accompanied by whole habitat drawings of typical examples with realistic backgrounds give users a high degree of confidence in correct assignation.

As is often the case with insects, naming ones captured to species level in several cases requires patience involving microscope work. The utility of mayflies in water quality assessment is well known. This requires accurate species identification and knowledge of their individual ecologies. This new publication provides for that process. The discussion of various mayfly studies in the context of stream drift is of interest. The principal author pioneered the British side of investigations into drift, in which the Ephemeroptera are a prominent part, starting in 1965. All the aspects covered in this work are comprehensively sourced; one rather encyclopaedic sentence is accompanied by references to 60 scientific papers.

E. Geoffrey Hancock

Lost Land of the Dodo

Anthony Cheke and Julian Hume

T & A D Poyser, London 2008, 464pp hardback with numerous figures, illustrations and maps, including a series of colour paintings of extinct and living species. ISBN 978 0 7136 6544, £45

The Dodo must be the most famous of all extinct birds. But it is only the sad flagship for a whole wildlife community that once existed on the islands of Mauritius, Reunion and Rodriguez in the Indian Ocean, and which has been destroyed or severely disrupted by human settlement. This book is more than just another account of wildlife on a tropical holiday destination. It is a major study of the impact and history of human settlement on island wildlife. The islands were uninhabited when first discovered and so the remarkable animals and plants found there had evolved in the absence of human contact. The islands were also on a major trading route from Europe to the Far East and so soon became visited by many passing sailing ships for water and supplies. Crucially, the first sailors and settlers to arrive there have left good records of what they found and saw. So there are better accounts of what happened to the dozens of species of giant tortoises, birds and bats which became extinct, and the habitat changes that man brought about. than for any other island archipelago in the world.

Darwin visited for a few days in 1836 but already by then the native species were so rare that Darwin never saw any - the only animals he found were introduced species. This will be the definitive account of the history and fate of wildlife in the Mascarene islands. One of the authors, Anthony Cheke, has had a lifetime fascination with the islands and his deep passion and commitment shine through this book. Both authors are research scientists but unusually they can convey their information in a most lively and often amusing way. This book is a genuine delight to read, always turning up strange and fascinating stories and facts. It is also a work of real scholarship. There are no less than 128 pages of appendices and chapter notes. This might sound profoundly dull but they contain so many strange and unexpected delights that you soon find yourself browsing for more. It is not intended as a holiday guide to the wildlife but anyone taking a holiday to the islands with a serious interest in wildlife will find this book infinitely rewarding. It is also not a totally bleak story. The book contains a chapter by Carl Jones on the development and successes of the conservation movement in Mauritius and the many success stories in species recovery and habitat restoration. Highly recommended.

David Houston

The Encyclopedia of Birds

Edited by Christopher Perrins

Oxford University Press, Oxford, 2009, 656 pages, paperback with colour illustrations, distribution maps and scale drawings. ISBN 978-0-19-956800, £19.99.

This is quite a heavy tome, at 656 quarto pages, printed on quality paper and full of illustrations. It covers the bird families of the entire world, and was issued in paperback form in September 2009. The editor, Christopher Perrins, is a fellow of Wolfson College, Oxford, was Professor of Ornithology at Oxford for 10 years and is a Fellow of the Royal Society.
Written by an international team of experts, it reflects the latest developments in zoology.
Accompanied by a comprehensive index, giving both common and scientific names, it covers bird families rather than individual species in detail.

In order to see what to expect of this book, I looked up a couple of common British species.
The Stonechat is merely mentioned once, as part of a treatment of behaviour in thrushes, and is said to defend its territory vigorously against potential predators.

Look in the index under Golden Eagle, and you will find no index entry. Under Eagle, Golden, you are redirected to *Aquila chrysaetoc*, rather than the usual *chrysaetos*, which is also mentioned elsewhere. Once at the several pages on the Hawks, Eagles and Old World Vultures, one learns about the Golden Eagle only that:

- Eagles of the genus Aquila feed on live prey as well as carrion, and about siblicide in which the older of two chicks normally kills the younger one.
- Home ranges of the Golden Eagle vary in size between 4500 and 7300 hectares.
- Certain nest sites are used for at least a century, and the nests may grow to an enormous size.

So, anyone expecting a page or a set of pages about a particular species will be disappointed. Despite the capacious nature of this tome, there is, necessarily and understandably (although also perhaps disappointingly), no coverage of individual species, but only of a whole family at a time. Since the scope of the book is the entire World, this is perhaps hardly surprising.
Rather than species accounts, the treatment is themed within the chapters about Families. It is these themes (behavioural and conservation topics) which make the book very readable, rather than being a species by species treatment. Themes to do with Hawks, Eagles and Old World Vultures include such topics as "Death on Wings", "Couples and Colonies", "Nowhere to Nest", "Top Predators at Risk", or "Preying on Livestock". The Factfile which accompanies each chapter lists the distribution, habitat, plumage, voice, eggs, diet and conservation status of a Family.

In conclusion, anyone could pick up this book and be delighted with a readable account of groups of bird

species, provided that one is prepared to rest this heavy tome somewhere convenient. It is hardly a laptop or bedside reading book! The photographs of representative species of each family are stunning, and the book is good value for its size and comprehensive nature, and worth having for the photographs alone.

David Palmar

An Odyssey with Animals: A Veterinarian's Reflections on the Animal Rights & Welfare Debate

Adrian R. Morrison.

Oxford University Press, 2009. 288 pages, hardback.
ISBN 978-0-19-537444-5, £19.99

Adrian Morrison is an American veterinary surgeon who is now Professor Emeritus of Behavioural Neuroscience at the University of Pennsylvania's Veterinary Medical School. It was here that he became widely known for his research into REM sleep using cats. (REM is a phase in sleep associated with rapid eye movement).

In the introduction the author explains how an attack on his laboratory by animal rights activists in 1990, was the catalyst which ultimately caused him to write this most interesting and very readable book, which at first glance appears to be a comparatively slim volume, but which in content is far from slim. "An Odyssey with Animals" is exactly what it says on its well designed dust jacket : "A veterinarian's Reflections on the Animal Rights and Welfare Debate".

In the early part of the book the reader is lead into the world of the experimental laboratory where the findings are discussed and explained. That Morrison loves his work is clear, as is the frustration and depression that followed the attack on his laboratory. He describes the Animal Rights Societies in the USA as being large, wealthy and powerful organisations, whose extremist members are regarded by the FBI as: "one of today's most serious domestic terrorism threats." (page 7).

He admits that at one time, along with other scientists involved in biomedical research, he was reluctant to stand up and be counted, such was the perceived threat from some such organisations. His attitude has now changed however, as has his acceptance that many moderate Welfare Soeieties can be a force for good.

As he reflects on animal welfare as a whole and on the use of animals in biomedical research in particular, Morrison makes a strong case for their continued use in this type of researeh. It is his contention that medical knowledge cannot progress without the use of animals at some stage and he reminds the reader of the huge benefits there have been to the health of humans and animals alike, thanks to such research. He goes on to point out that effective legislation has been in place since 1985 in the USA to ensure that animal experimentation is carried out in a humane manner and in approved laboratories which are regularly inspected by the authorities. America has in this respect followed the lead of the UK, which had such laws in place more than a century before. Efforts are now made to keep animal experiments to a minimum and to use analgesics (pain relieving drugs) even when the animal is showing no overt sign of pain. There can be no doubt that Morrison loves animals. There are many references to his pet cat Buster. It is his contention, and I agree, that animals cannot contemplate their own death. Were this to be otherwise Morrison says he could not have conducted the research he did.

The many other uses man makes of animals are considered as are the ways in which these are viewed. As someone who spent his boyhood on a farm, Morrison's perception of what is or is not good practice may differ from that of many young people of today, whose understanding and experience of the countryside may now be remote. He does express concern that in the world of food production, commercial considerations will sometimes take precedence over that of animal welfare. I agree, and believe that the poultry industry on both sides of the Atlantic may be an example of this.

In the final part of the Odyssey we return to the Welfare Debate, this time with the "Philosophers". Here the author discusses the views of those with whom he most strongly disagrees, using quotations from the writings of many erudite individuals to support his own arguments. Morrison has by now, however, modified some of his opinions and, to illustrate this, tells of how he had even invited a new " animal rightist" friend (page 221) to deliver a lecture to his students.

This is a most thoughtful and thought provoking book. It is very well written and researched. (There are more than three hundred references.) I recommend it,
in particular to anyone with a scientific background.

Margaret Stead

The World from Beginnings to 4000 BCE

Ian Tattersall

New Oxford World History, Oxford University Press, Oxford 2008, 143 pp hardback with b & w illustrations and photographs. ISBN 978 0 19 516712 2 hardback £10.99 and 978 0 19 533315 2 paperback.

Despite the rather misleading title, this is a book on human evolution. Yet another. There are so many books in this field that the first question must be, what does this one offer thatn the others don't. One answer is brevity – at only about a hundred pages it offers a snappy introduction that is also authoritative and reasonably up to date. The author is a prolific research scientist on the human fossil record and curator of Anthropology at the American Museum of Natural

History. Perhaps we should also add that it is cheap! The book is part of an OUP series on World History and is clearly aimed at the general reader who may be new to biology. So there are general introductions to the process of evolution, how fossils are formed and how animals are classified. It gives a good summary of the key stages in human evolution, dealing with information from DNA and other molecular techniques as well as the classic fossil and archaeological evidence. The book is clearly written and does provide a handy and accessible introduction to what can be a rather complicated story.

David Houston

Wildlife Around Glasgow. 50 Remarkable Sites to Explore

Richard Sutcliffe and over 40 other authors

Glasgow Museums, 2010. 176 pages, softback, ISBN 0902752960, £9.99.

This is an excellent and inexpensive book that caters for a wide range of tastes. Don't be put off by its initial appearance which may remind you of Glasgow Corporation and its associated political correctness. The format resembles "Archaeology Around Glasgow: 50 Remarkable Sites to Visit" also published by Glasgow Museums. In the wildlife book those interested in natural history will find a remarkable depth of knowledge and be continually surprised by new aspects of a wide range of natural history, including geology and soils, as well as animals, plants, fungi and trees. If on the other hand you want to know about green and pleasant places to go for a walk in that are reached easily from Glasgow, this book is also useful.

On Christmas day every year, rather than spend all the day indoors, I like to go somewhere to take exercise with my family. It has to be reasonably accessible and not too rough ground. Reading the book gave a wide choice of venues and we chose this year to go to Ardmore Point near Cardross on the Clyde Estuary. This turned out to be a 3km walk around a coastal promontory with great views on all sides and amazing sea birds in large numbers. The book describes its interesting geology but we will have to return on a warmer day when the rocks are not covered in snow. The place is surprisingly wild and natural, including the thick gorse that impedes progress at one point in the walk.

The other site near my home in the book is Loch Libo. The loch itself is a half mile long and is in the valley, surrounded by trees, just beside Uplawmoor. I thought I knew about its wildlife (clumps of aspen, tufted sedges, bogbean, an assortment of ducks, grebes and Whooper swans), but it turns out there are many other forms of life I had not seen (more sedges, a poisonous plant called cowbane and water voles which are now rare in Scotland). The site is owned by Scottish Natural Heritage and you also have to cross the railway line to get in to it, which puts many people off, so you are unlikely to meet anyone except a few fishermen. Without a guidebook like this you might miss it, which would be a shame.

An interesting part of this book is the Introduction. It provides intriguing information about the local history of Glasgow landscapes since the ice age. I was unaware that 6,000 years ago our climate went through a period when it was both hotter and drier than it is now; at that time it was mainly covered by forest. This is not to be confused with the medieval period about 1,000 years ago when there was another, but slightly less pronounced, warm period compared to the present. The main changes in plants and animals are described, some of which are recent. The large amounts of de-icing salt put on roads during the winter has given rise to the presence of salt-tolerant grasses, that otherwise grow near the sea, along motorways and bus routes.

A Student's Guide to the Seashore (third edition)

J D. Fish & S. Fish

Cambridge University Press, Cambridge. 2011. 527 pages, paperback with 408 line drawings and 32 colour plates. ISBN 978-0-521-72059-5, £35.

'Fish & Fish' has been a successful guide to the seashore because it meets the needs of a varied readership. As both an identification guide and a source of information on the biology of littoral organisms, it has proved useful to students, secondary and tertiary educators, and amateur naturalists. The second edition was "the first choice of students of marine biology in NW Europe", according to the publisher. The third edition, appearing after a 15 year gap, is likely to maintain this position. It covers more species than did the previous two editions (over 650, compared with the second edition's 600 and the first's 500), and now includes introduced species, such as the invasive wireweed *Sargassum muticum* and carpet sea-squirt *Didemnum vexillum* (both now present in the Firth of Clyde); the taxonomy and the biological information on individual species have been updated; and the book is "now enhanced" with 32 colour plates.

The general format of the previous editions has been retained. After a brief introduction to tides and different shore types, there is an "Illustrated Guide" in the form of an identification key enabling organisms to be quickly assigned to a phylum and class, which has been reorganised and made more user friendly. The rest of the book is a series of chapters, each devoted to a major plant group or animal phylum and including dichotomous keys to families (where appropriate) and species. The diagnostic features of each species are described and an overview of its biology is provided.

Changes in the formatting of the headings, such as all headings being in a sans serif font and class and sub-class names being 'boxed', are improvements that make it easier for readers to find their way around the third edition than the previous two. Most species are still illustrated with detailed and accurate line drawings. Although there are a few entirely new drawings, and some new labelling and insets have been added to others, the majority remain unchanged, except that they are now set against a pale grey background. Whilst no doubt the latter feature has been introduced to give the book a more contemporary appearance, it has unfortunately resulted in a slight reduction in the sharpness of the drawings, which made me wonder why aesthetic design considerations should have taken priority over scientific clarity. The first edition included four colour plates, which were omitted in the second edition. The return of colour in the form of 32 plates (including some photographs carried over from the first edition) is a welcome bonus, perhaps made affordable by the economics of digital technology; some groups, such as the lichens, are illustrated only in colour photographs, and distinctions between certain easily confused species, notably limpets, are clarified. It is regrettable that, as in the previous editions, no scale-bars are given in any line drawings or photographs. The authors continue to justify this by stating that sizes are included in the diagnostic information. However, this is not always the case (e.g. there are no indications of size for the majority of lichens), and to identify some organisms you have to oscillate between keys, diagnostic information and drawings all on different pages. The presence of scale-bars would have eliminated the need for at least some of this page flipping. This is a minor irritation, which does not detract from the overall usefulness of the book.

'Fish & Fish' is too big and heavy to be practicable as an aid to identifying specimens in the field, and so, on this score anyway, it cannot compete with any of the currently available pocket-sized identification guides. It can, however, be recommended unreservedly for indoor-based identification work and as a preliminary source of information on the life-cycle and ecology of individual seashore organisms.

Iain C. Wilkie

The Glasgow Naturalist (online 2012) Volume 25, 157-158

Proceedings 2010

The chair, place, lecturer's name and title of lecture are given for most meetings. GKB - Graham Kerr Building. All meetings were well attended.

13th January
Visit to University of Glasgow Library to see natural history books in their special collection.

28th January
Roger Downie, GKB. Lecture from Rosin Campbell-Palmer, "Re-introducing beavers to Scotland". Held jointly with Glasgow University Zoological Society.

9th February
Roger Downie, GKB. Lecture from Heather McHaffie, "Scottish plants at the Royal Botanic Gardens, Edinburgh".

23rd February
Roger Downie, GKB. 80th AGM followed by a lecture from Debbie McNeill, "Great crested newts in Scotland, and the Gartcosh translocation".

9th March
Roger Downie, GKB. Members' photographic night. Preceded by a tutorial from Jeanne Robinson, "Orthoptera - grasshoppers and their allies".

13th April
Roger Downie, GKB. Lecture held jointly with Hamilton NHS and Paisley NHS from Mel Tonkin, "Red squirrels". Preceded by a tutorial from Eilidh Spence, "The Glasgow Living Water Project".

11th May
Roger Downie, GKB. Lecture from Willie Yeomans, "Clyde River Trust".

Excursions
Including the summer social 20 day excursions and 2 weekend excursions were held throughout the year.

14th September
GKB. Exhibition meeting with wine and cheese.

6th October
GKB. Blodwen Lloyd Binns lecture and presidential address from Roger Downie, "Adventures with amphibians".

30th and 31st October
Weekend Conference on Urban Biodiversity.

9th November
Roger Downie, GKB. Lecture from Sarah Cleveland, "Wildlife disease research in Africa: protecting the health of parks and people". Preceded by tutorials from Maggie Reilly and Anne Orchardson on "Elizabeth Gray's fossils and Hannah Robertson's marine biology".

18th November
Roger Downie, GKB. Lecture from Shanan Tobe, "Tigers and Leopards and Bears, Oh My!! Identification of Endangered species in Traditional East Asian Medicines". Held jointly with Glasgow University Zoological Society.

14th December
Christmas Dinner at Café Connect followed by a talk from David Hawker, "An island biosphere: Menorca's plants".

Officers and Council elected at the 2010 AGM

President
Roger Downie, BSc, PhD

Vice Presidents
John Knowler, PhD
Bob Gray, BSc, MBiol

Councillors
Lindsay Gemmell
Susan Futter

General Secretary
Mary Child, BSc, MEd
Assistants
Lynn Dunnachie Council Meetings
Anne Orchardson Minute Book
Avril Walkinshaw Social
Roger Downie Winter programme

Treasurer
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Membership Secretary
Richard Weddle, BSc

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Janet Palmar, BSc, PhD
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Editor
Dominic McCafferty, BSc, PhD
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Edna Stewart Botany
Anne Orchardson Excursions

David Palmar Ornithology
David Palmar Photography

BLB Executive
President, Secretary, Treasurer
Scientific Advisors Peter Macpherson FRCP. FRCR, DTDC, FLS and John Knowler
Technical advisor Richard Weddle

Proceedings 2011

The chair, place, lecturer's name and title of lecture are given for most meetings. GKB - Graham Kerr Building. All meetings were well attended.

11th January
Roger Downie, GKB. Tutorial and lecture from Colin Wolfe, "Inspired by the natural world".

3rd February
Paisley Museum. Joint lecture with Paisley NHS.

8th February
Roger Downie, GKB. Lecture from Keith Watson, "Flora of Renfrew". Preceded by a tutorial from Zara Gladman on crayfish.

22nd February
Barbara Mable, GKB. 81st AGM followed by a lecture from Richard Tipping, "Moments of crisis: past climatic changes and their impacts in Scotland".

8th March
Barbara Mable, GKB. Members' photographic night. Preceded by a tutorial from Tom Prescott, "Biodiversity and management of aspen".

12th April
Barbara Mable, GKB. Lecture from Iain Wilkie, "Autotomy and other animal detachment mechanisms in the home, garden and beyond"

10th May
Barbara Mable, GKB. Lecture from Barbara Mable, "Evolution of plant reproductive systems in changing environments". Preceded by a tutorial from Jon Barnes on intertidal Scottish crabs.

Excursions
Including the summer social 24 day excursions and 2 weekend excursions were held throughout the year.

20th September
GKB. Exhibition meeting with wine and cheese.

October 11th
Barbara Mable, GKB. Lecture from Scott Wilson, "Introduced tree species in Scottish forests: recruits, renegades or refugees?". Preceded by a tutorial from Roy Watling, "In the footsteps of Frederick Klotzch: fungi and mycologists past and present".

8th November
Barbara Mable, GKB. Lecture from Keith Cohen, "The bats of Scotland and Trinidad". Preceded by a tutorial from Crispin Hayes, "Working towards a revival of the Clyde Valley orchards".

16th November
Barbara Mable, GKB. Blodwen Lloyd Binns Lecture from Richard Abbott, "Plant speciation in action in the UK: tales of the unexpected".

13th December. Christmas Dinner at Café Connect followed by a talk from David Bradley and Emily Waddell, "A contrast in expedition locations: Iceland and Peru".

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Avril Walkinshaw Social
Roger Downie Winter programme

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Membership Secretary
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George Paterson Zoology

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Technical advisor Richard Weddle
Financial Advisor Bob Gray

The Glasgow Naturalist

Advice to Contributors

1. The Glasgow Naturalist publishes articles, short notes and book reviews. All articles are peer reviewed by a minimum of two reviewers. The subject matter of articles and short notes should concern the natural history of Scotland in all its aspects, including historical treatments of natural historians. Details of the journal can be found at www.gnhs.org.uk/publications.html

2. Full papers should not normally exceed 20 printed pages. They should be headed by the title and author, postal and email address. Any references cited should be listed in alphabetical order under the heading References. All papers must contain a short abstract summarising the work. The text should normally be divided into sections with sub-headings such as Introduction, Methods, Results, Discussion and Acknowledgements.

3. Short notes should not normally exceed one page of A4 single-spaced. They should be headed by the title and author's name, postal and email address. Any references cited should be listed in alphabetical order under the heading References. There should be no other sub-headings. Any acknowledgements should be given as a sentence before the references. Short notes may cover, for example, new locations for a species, rediscoveries of old records, ringed birds recovered, occurrences known to be rare or unusual, interesting localities not usually visited by naturalists, and preliminary observations designed to stimulate more general interest.

4. References should be given in full according to the following style:

Pennie, I.D. (1951). Distribution of Capercaillie in Scotland. *Scottish Naturalist* 63, 4-17.

Wheeler, A. (1975). *Fishes of the World.* Ferndale Editions, London.

Grist, N.R. & Bell, E.J (1996). Enteroviruses. Pp. 381-90 In: Weatherall, D.J. (editor). *Oxford Textbook of Medicine*. Oxford University Press, Oxford.

5. An organism's genus and species should be given in italics when first mentioned. Thereafter the common name is only required. Please use lower case initial letters for all common names e.g. wood avens, blackbird; unless the common name includes a normally capitalised proper name e.g. Kemp's ridley turtle. The nomenclature of vascular plants should follow Stace, C.A. (1997). *The new Flora of the British Isles*, (Second Edition). Cambridge University Press, Cambridge. Normal rules of zoological nomenclature apply. When stating distribution, it may be appropriate to give information by vice-county.

6. All papers, including electronic versions, must be prepared on A4, double spaced throughout, with margins of 25mm, with 12 point Times New Roman font. Tables and the legends to figures should be typed separately and attached to the end of the manuscript. The Editor can make arrangements to have hand-written manuscripts typed if necessary.

7. Tables are numbered in arabic numerals e.g. Table 1. These should be double-spaced on separate sheets with a title and short explanatory paragraph underneath.

8. Line drawings and photographs are numbered in sequence in arabic numerals e.g. Fig. 1. If an illustration has more than one part, each should be identified as 9 (a), (b) etc. They should be supplied as a high resolution digital image or camera-ready for uniform reduction of one-half on A4 size paper. Line drawings should be drawn and fully labelled in Indian ink, dry-print lettering or laser printed. A metric scale must be inserted in photo-micrographs etc. Legends for illustrations should be typed on a separate sheet. Photographs are normally printed in black and white, however the Editor is able to accept a small number of high quality colour photographs for each issue.

9. Articles should be submitted to the Editor: Dr Dominic McCafferty by email dominic.mccafferty@glasgow.ac.uk either as a single word processed document or pdf. Photographs and illustrations should be high resolution with a minimum of 300 dpi in tif or jpeg format. Please contact the Editor if you require assistance with photographs as in some cases suitable photographs can be obtained.

10. When the article is accepted for publication, the author should return the corrected manuscript to the Editor as soon as possible. Final proofs should be returned to the Editor by email / return of post. Alterations at this stage should be kept to the correction of typesetting errors. More extensive alterations may be charged to the author.

11. A copy of the published article will be sent to the first author as a pdf file. Ten reprints will be supplied free of charge for full papers only. Additional reprints required will be charged at extra cost.

12. All submissions are liable to assessment by the Editor for ethical considerations, and publication may be refused on the recommendation of the Editorial Committee.